ENGINEERING | AND | SCIENCE

November 1958

Nobel Prizewinner . . . page 17

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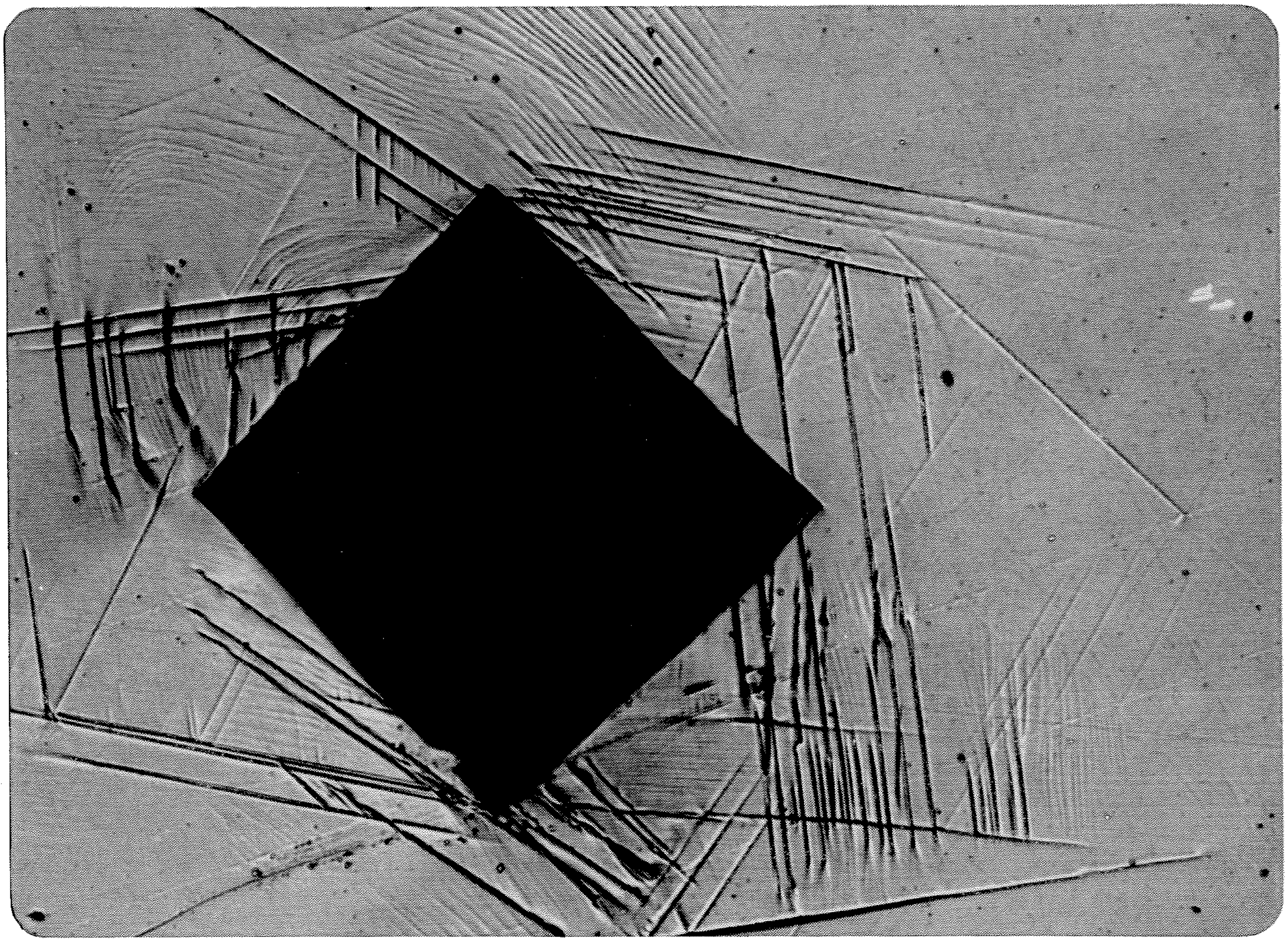

ENGINEERING | AND | SCIENCE

NOVEMBER, 1958 VOLUME XXII NUMBER 2

On Our Cover

George W. Beadle, chairman of Caltech's biology division, and winner of the 1958 Nobel Prize in medicine. Dr. Beadle is the seventh Caltech man to receive a Nobel award. For the details, see page 17.

Gary Boyd

who wrote "Plasma – The Fourth State of Matter" on page 34 has been at Caltech since 1950, when he entered as a freshman. He got his BS in 1954 and his MS in 1955, and is now working for his PhD. Plasma research has been Gary's main field for several years. The tube and the experiments he describes in his article were conceived jointly by himself, Lester Field, professor of electrical engineering, and by Roy Gould, associate professor of electrical engineering.

Ian Campbell

professor of geology at Caltech, presents some impressive facts about the need for extended mineral research in "The Industrial Minerals" on page 20. This article has been adapted from Dr. Campbell's address as retiring president of the Pacific Division of the American Association for the Advancement of Science at Utah State University last June.

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Books

The World of Science

by Jane Werner Watson

Simon and Schuster $4.95

Reviewed by Cleve Moler '61

How fast does a glacier flow?

How do we measure the distance between galaxies?

What is a set?

How do we find a cosmic ray?

What holds atoms together in a molecule?

What is a virus?

How strong should a dam be?

The young people in today's scientifically-oriented world are asking these questions. High school and junior high, even college and elementary school students want the answers. And if no one will give them the answers, they want to find out for themselves.

It is especially for these young people that Mrs. Watson has written *The World of Science.*

In the words of the Foreword, written by Dr. E. C. Watson, Dean of the Faculty at Caltech, "This book deals with some of the questions that are turning up in scientific research today. It does not attempt to give all the answers nor to cover any field of science completely. It does, however, take you out to the frontiers of knowledge and provide you with a fair sampling of the kinds of work awaiting young men and women in the various fields of science and engineering. It is also accurate in its presentation of not only the results, but also the methods and – most important – the spirit of the investigations it describes."

Mrs. Watson is as skilled a writer as her husband is a scientist. The result is a book that is interesting and easy to read, but at the same time challenging and informative.

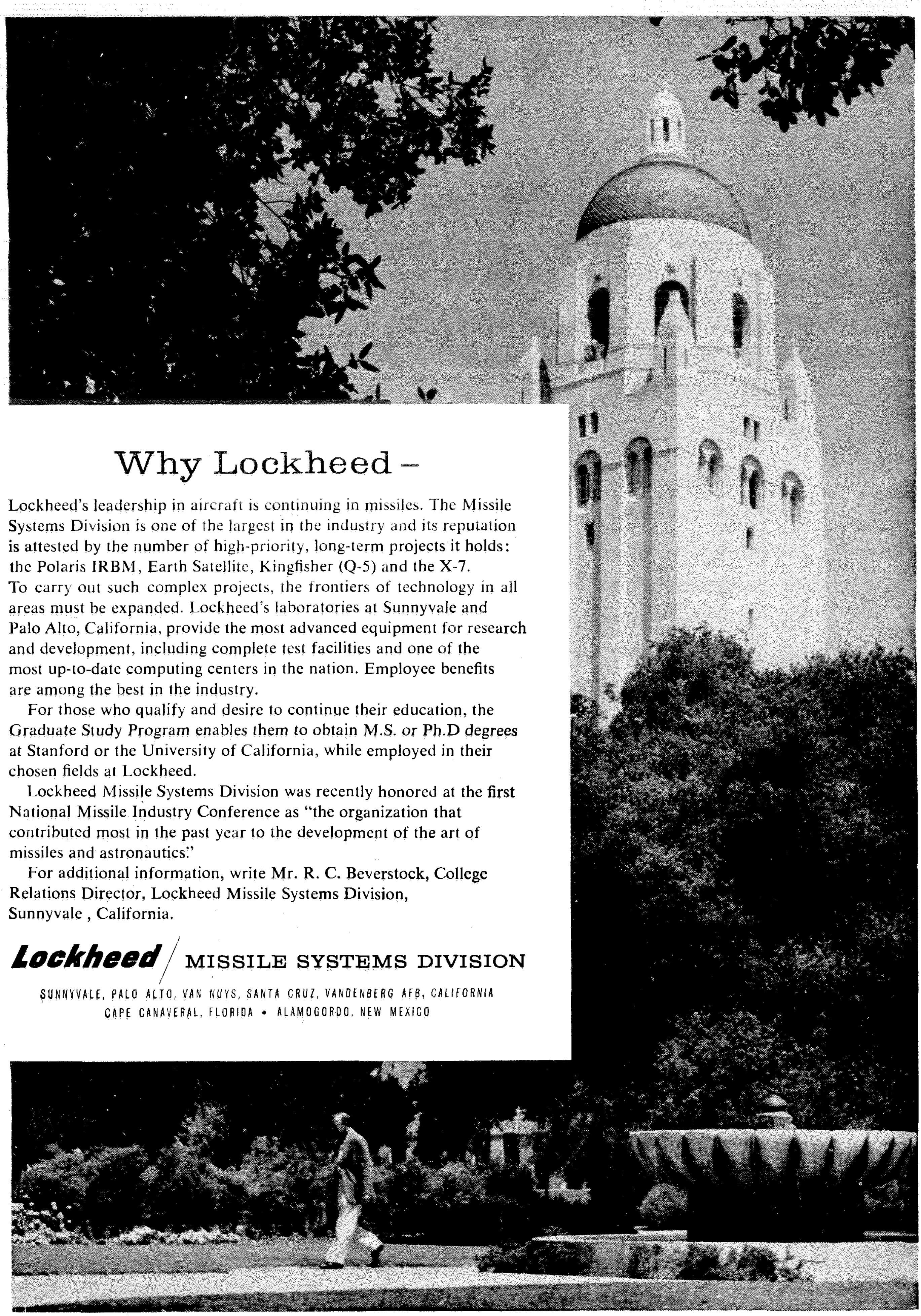
We look over the shoulders of geologists, astronomers, physicists, mathematicians, chemists, biologists and engineers at the experiments they are doing, the concepts and methods they use and the problems they face. We see what a scientist is like and what he does. For a high school freshman who wants to be a physicist, this is important.

The scientists are pictured as nice, average people who enjoy their work and who have their problems like everybody else. ("In comes a geochemist. He does not look like a scientist on television. He is a young man wearing slacks and open-throated shirt.")

Each chapter opens with an almost story-like picture of a scientist at work. ("It is moonless and dark on Palomar Mountain. The night cold creeps about the gleaming observatory dome. Inside the dome, the air is scarcely less cold. For the observatory is carefully insulated . . . A man wearing an electrically heated suit steps out onto the floor. For a moment he blinks at the eerie darkness where monster shadows lurk and tiny red signal lights glow . . . Then the man steps onto a small railed elevator platform and presses a button.")

The narrative then begins, using the nomenclature and the symbology of the science and, before you realize it, you're in the midst of a discussion about the types of galaxies or the

continued on page 10



concept of a set.

A comment should be made about the color photographs and diagrams. The jacket blurb says there are about 265 of them and they're all well done.

The World of Science will be particularly interesting to anyone connected with Caltech. Most of the projects described are going on at Tech and many of the photographs are of Institute personnel and Institute labs.

If criticism could be made, it would be that the book is *too* well written and produced. At a glance, a high school student interested in science might think it was a glorified picture-book with some dramatized generalizations about things he already understands. It isn't obvious that the book contains information and ideas new to a Caltech sophomore, but written so that most of it can be understood by a good student in 7th or 8th grade. My review copy was picked up many times from my desk by curious friends in the Caltech student houses. More than once a comment like, "Say, this is actually pretty good," was heard.

One final word of warning should be given to any mothers and fathers who plan to get this book. Don't be surprised if you find yourself up late some night reading about computers or immunology long after your 14-year-old has gone to sleep.

Elementary Seismology

by Charles F. Richter

W. H. Freeman and Company, San Francisco *$12*

Reviewed by Beno Gutenberg

If you are interested in earthquake problems – for example, the nature of the motion which shakes the ground, or the instruments which record the earthquake waves, or the depths in the earth at which the motion starts which produces the shaking at the surface, or if you want to know where earthquakes are frequent, or how they are located at a seismological observatory – then this is a book for you.

For 30 years Charles Richter, professor of seismology, has done successful research at Caltech's Seismological Laboratory. For most of this time he has supervised the measuring of seismograms, their interpretation and the reporting of the findings. When you read in the newspaper or hear over the radio that Caltech has located an earthquake of magnitude 7.2 about 6,500 miles southwest of Pasadena, this is nearly always the result of his work.

During the last 30 years, after each earthquake in southern California which was large enough to do some damage he went as soon as possible into the field to study the effects of the shocks and to investigate aftershocks, when possible, with instruments. He has published many papers on specific earthquakes.

In New Zealand, Dr. Richter spent most of two months comparing earthquakes and their effects with those in California. It is generally known that he originated the earthquake magnitude scale in California. Considering this wide background, it is not astonishing that *Elementary Seismology* does not have its counterpart as a source of information on earthquakes for educated readers.

The book was developed from lecture notes for a course on elementary seismology given by Dr. Richter at Caltech, mainly for students majoring in geology who do not want to specialize in seismology or geophysics. Mathematical derivations are generally restricted to appendices of the book which, in addition, contain several lists of earthquakes. Others of these 17 appendices give tables and graphs for transmission times from various focal depths, charts for the calculation of magnitudes, methods and tables to locate nearby shocks, and a list of selected seismological stations.

There are many illustrations showing earthquake faults or effects. Maps of epicenters, partly with indications of the geology, and various types of sketches illustrate the relationship between earthquakes and geological structure. Charts connected with seismogram interpretation and reproduced seismograms aid in the understanding of the chapter on interpretation of records.

A detailed index of 30 pages makes it easy to find information on specific earthquake problems, on the seismic history of a given region or on results of a specific author.

Beno Gutenberg, professor of geophysics, has been on the staff of Caltech's Seismological Laboratory for 28 years, and was director of the laboratory for eight years until his retirement from that position in 1957.

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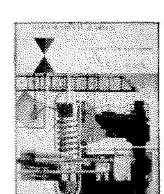


Letters

Pasadena

SIRS:

In the October issue of *E&S* Brad Efron's article "The Three-One Plan" presents the Old Dorm as "the first pitfall to be avoided."

I wonder whose research made "dollar-a-day East L. A. rooms" seem so preferable? He tempts me to waste a bit of film on a few such flea bags, but little things bother me.

Verily, a NEW DORM is needed to replace the present firetrap, but I trust the alums are discerning enough to note that Brad's graphic illustration of the comfortable life does *not* show his off-campus retreat, but pictures one corner of the Old Dorm's Room 28, for which each of its two oppressed occupants pays 63 cents per day.

Ruth Toy, Mechanical Engineering Secretary, Caltech

DEAR MRS. TOY:

I'm afraid I've been guilty of initiating the type of controversy which could never be settled satisfactorily by either of us. I, by choice, will never stay in a dollar-a-day East L. A. room, while you, by whim of nature, will never live in the Old Dorm. Nevertheless, I did feel somewhat qualified to expend my literary licentiousness on the Old Dorm, having

1 – Listened to Dr. Sorensen's speech during last September's Development Program ceremony.

2 – Done a bit of original research on the subject myself. (Did you know that the Old Dorm is an "airy, modern, California-styled bungalow?"– *1919 Little T.)*

3 – Lived there for one summer.

Let me admit that my months at the Old Dorm were among the happiest of my life. I was working, but not overworking, well-fed, but not overeating, and in love, but not on the verge of marriage. Nevertheless, the splintery walls and archaic plumbing of my surroundings were a definite drag on my euphoria.

I will emphasize again that Mrs. Lyall and her crew do a remarkable job with what they have. They just don't have much. Assuredly, I will drink a toast with you (having passed legal age) when Mrs. Lyall snaps the ribbon on the NEW Dorm. Until then, you will please direct any complaints you have concerning photography to Ed Hutchings, 2 Throop. Thank you for your interest.

Brad Efron '60

Cincinnati, Ohio

SIRS:

I may have missed an issue of *Engineering and Science* but to date I have seen no mention of *Mark Mills'* untimely death at Eniwetok on April 7, 1958. *(E&S, Apr. '58, p. 34 – Ed.)*

I am sure that Mark, who got his BS in 1940 and his PhD in 1948 at Caltech, had a multitude of friends among the alumni and faculty. He brought great credit to his school, and his passing should be properly acknowledged in the magazine.

Mark, as assistant director of the

continued on page 46

George W. Beadle

Nobel Prizewinner

Dr. George W. Beadle, chairman of Caltech's division of biological sciences, is one of three American scientists to be awarded the 1958 Nobel Prize in medicine.

The three men were all honored for achievement in biochemical genetics. Dr. Beadle and Dr. Edward L. Tatum, now of the Rockefeller Institute in New York, share one-half of the $41,250 award for their discovery that genes act by regulating definite chemical events. The other half of the award goes to Dr. Joshua Lederberg, of the University of Wisconsin, for his discoveries concerning genetic material of bacteria.

Dr. Beadle, who is on leave from the Institute this year to serve as Eastman Visiting Professor at Oxford University in England, is the fifth Caltech faculty member to receive a Nobel Prize.

In 1923 the late Dr. Robert A. Millikan, professor of physics and chairman of the Caltech Executive Council from 1921 to 1945, received the Nobel Prize in physics for his work on the determination of the charge of the electron.

In 1933 the prize in medicine and physiology was awarded to the late Thomas Hunt Morgan, professor of biology and chairman of the division of biology from 1928 to 1944, for his theory of the gene and his studies of heredity and genetics.

Carl Anderson, professor of physics and an alumnus of the Institute, received the 1936 prize in physics for his discovery of the positron.

Linus Pauling, who received his PhD from Caltech in 1925, and has been professor of chemistry here since 1931, was awarded the prize in chemistry in 1954 for his research on the nature of the chemical bond.

Two Caltech alumni have won the Nobel Prize. Edwin M. McMillan '28, MS '29, who is now professor of physics at the University of California in Berkeley, shared the 1951 prize in chemistry with Glenn T. Seaborg, for their joint discoveries of six radioactive elements which were used in the development of atomic energy.

William Shockley '32, director of the Shockley Semiconductor Laboratory of Beckman Instruments, Inc., shared the 1956 Nobel Prize in physics with Walter Brattain of Murray Hill, N. J., and John Bardeen of Champaign, Ill., for their work in inventing and developing the transistor.

How genes work

The Beadle-Tatum discovery that won them the 1958 prize gave science its first clue as to how genes actually work. Before 1941 there were some indications that genes controlled chemical reactions, but this was not a widely accepted fact. In that year, though, Beadle and Tatum, working at Stanford University, made the significant discovery that the synthesis of vitamins and amino acids in the living cell is under the control of the genes. This in turn suggested that each of the biochemical reactions of a cell is governed by a particular gene.

This discovery opened up a whole new field of research which has led to new knowledge of genes themselves, to new knowledge in biochemistry, and even in bacteriology – where, for the first time, it made possible the study of bacterial genes. In making their discovery the men used the red bread mold *Neurospora Crassa*, and they have been identified not only with the discovery but with the addition of this new tool for genetic research.

George Beadle has worked extensively with all three of the organisms that are of major importance in the development of theoretical genetics – maize, *Drosophila* and *Neurospora*.

A native of Nebraska, Beadle was born in Wahoo in 1903. He got his BS (1926) and MS (1927) degrees at the University of Nebraska's School of Agriculture, then went to Cornell University. There he became seriously interested in genetics and made important contributions to the genetics and cytology (study of cells) of corn.

After he got his PhD in 1931 Beadle came to Caltech as a National Research Council Fellow. Here he began his work on the fruit fly, *Drosophila*, under Thomas Hunt Morgan. In 1935 he left Caltech and went to Paris to work with Dr. Boris Ephrussi, of the University of Paris, whom he had met at the Institute. The men hoped to find a way of analyzing in biochemical terms certain of the heritable characteristics which geneticists had discovered in *Drosophila*. Up to this time geneticists had been concerned primarily with establishing the existence of the genes and with studying their mode of transmission from one generation to the next. But not much had been done on the mode of action of the genes – the means by which they carry out their control of the structure and the function of the body. Before this work could be done there needed to be some understanding of the biochemical processes leading up to the final, visible expression of the gene.

Beadle and Ephrussi began studies of certain inherited defects in eye-pigment production in *Drosophila*. In a series of papers published during the next five years they were able to show that a gene controls the eye-color by producing a certain chemical substance.

After a year on the biology faculty at Harvard, Beadle went to Stanford as professor of biology in 1937. As he continued his research, it became clear that he needed a simpler organism than *Drosophila* for his biochemical studies. In 1941, then, working with Edward Tatum, he found that the red bread mold *Neurospora* was an ideal tool for these studies – and found, using this tool, that genes control the synthesis of vitamins and amino acids in the living cell.

Dr. Joshua Lederberg later worked with Dr. Tatum, applying some of the techniques of the mold studies to bacteria, and discovering that some strains could be made to cross, and that their offspring received new heredity factors in the crossing.

An expansive chairman

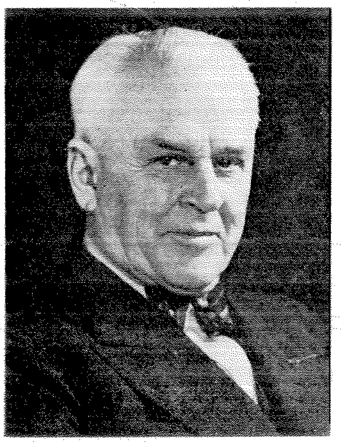
In 1946 Beadle became chairman of the Caltech biology division, succeeding the late T. H. Morgan. The division has been in a constant state of expansion ever since. With natural enthusiasm and enormous energy Beadle has built his department into one of the best in the country – both in terms of personnel and facilities.

He runs this bustling department in a relaxed and permissive atmosphere (some people have *never* heard him say "No") which turns out to be highly efficient.

As an administrator, fund-raiser, teacher and lecturer, there are constant demands on Beadle's time – particularly for his popular talk on heredity, which he has probably given between 50 and 100 times to date. (This talk includes his favorite definition of heredity, coined by a harried freshman on a biology examination at Stanford: "Heredity is where if your grandparents didn't have any children, you probably won't either.")

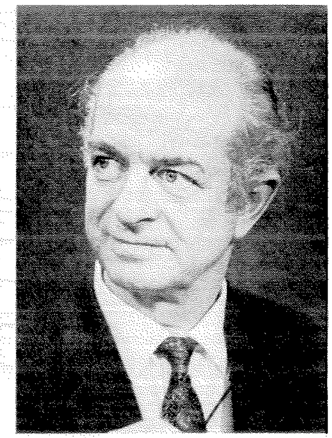
Time, however, is something Beadle manages to find for everything. He lives with his wife and 15-year-old son in the early-California-style ranch house that used to belong to T. H. Morgan – and which is

Past Prizewinners


R. A. Millikan
1923 prize in physics

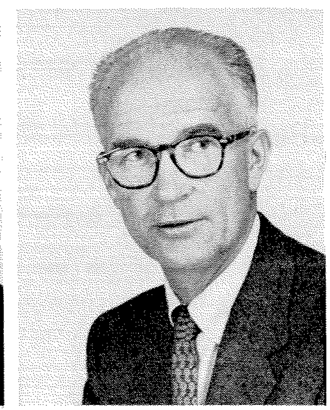

Thomas Hunt Morgan
1933 prize in medicine


Carl Anderson
1936 prize in physics


Linus Pauling
1954 prize in chemistry

Six other Caltech men who have won Nobel awards


Edwin M. McMillan
1951 prize in chemistry


William Shockley
1956 prize in physics

located directly across the street from Beadle's office on campus. This leads inevitably to a certain amount of blending of Beadle's home and professional life. He is an ardent gardener, but the impressive flowers and corn he produces in his home garden are also grown for genetic studies, too. So are the Siamese cats he raises. His interest in mountain and rock climbing is pure and unadulterated, however; once, with two equally-dedicated Caltech colleagues he made a two-week trip to a remote section of Alaska to climb a mountain that had never been climbed before.

Beadle is past president of the American Association for the Advancement of Science and of the Genetics Society of America. He has received honorary degrees from a number of universities, including Nebraska, Northwestern and Yale. He is a member of the National Academy of Sciences, the American Philosophical Society and the Royal Danish Academy of Sciences. He is co-author (with his Caltech colleague A. H. Sturtevant) of *An Introduction to Genetics*, published in 1939. Among other awards, he received the American Public Health Association's Lasker Award in 1950, and Denmark's Emil Christian Hansen Prize in 1953.

"I am, of course, happy and grateful to share the high honor," he said when he was told last month that he had won the 1958 Nobel Prize in medicine. "At the same time, I am more than ever aware that my own personal contribution to the science of heredity has been a small one, and I should not have made it had I not had the good fortune to be associated with able and generous co-workers and generous teachers."

When Caltech got the word that Beadle had received the Nobel award, 29 biology graduate students sent a congratulatory wire to their chief in England: TREMENDOUSLY PLEASED AND PROUD OF YOU COME HOME BRING MONEY.

Beadle promptly wired back: THANKS FELLOWS YOU TOO CAN WIN NOBEL PRIZES STUDY DILIGENTLY RESPECT DNA DON'T SMOKE DON'T DRINK AVOID WOMEN AND POLITICS THAT'S MY FORMULA.

The Industrial Minerals

They used to be the poor relations of the mining world. Today they look more like the pace-setters.

by Ian Campbell

Industrial minerals, for a long time, were known to economic geologists as "the nonmetallics." These were the minerals sought, not for their content of a metallic element (as we seek galena for its content of lead), but for some industrially useful property that was perhaps inherent in the mineral just as it came from the ground (diamond or native sulphur), or which could be developed by a treatment that did not require reduction to an element (the conversion of limestone and shale in a kiln into Portland cement).

The nonmetallics are a large and diverse category, including such common things as sand and clay, and such relatively rare materials as sheet mica (for dielectric uses) and zircon (for high-grade refractories).

Economic geologists and mining engineers of the past generation looked down on the nonmetals. Some still look down on them – even though, in terms of our national economy, the value of the annual output of the industrial minerals in each year since World War II has exceeded by several millions of dollars the value of the annual output of the metalliferous minerals.

The industrial minerals have been the poor relations of the mining world. They have lacked the glamor of the metals. There have been very few bonanzas among industrial mineral deposits, and there have been few easygoing profits. As a result the industrial mineral industry well deserves to be compared with our packing industry, which has long claimed that in order to make any profit it must utilize "everything but the squeal of the pig." This has been one of the major contributions to mineral development that has stemmed largely from the industrial minerals – the recognition of the importance of by-products and the development of methods to handle them.

"The Industrial Minerals" has been adapted from Dr. Campbell's address as retiring president of the Pacific Division of the American Association for the Advancement of Science at Utah State University on June 16, 1958.

Parenthetically, it is of interest to note that in recent years, just as nonmetals have graduated to the more positive and dignified term, "industrial minerals," so have many by-products been graduated to the more dignified term of "co-products"! Let me take an illustration from the USSR, both because it will give credit where credit in this case is surely due, and because it will illustrate some other factors of mineral economics.

Prior to the first world war, Russia had obtained the bulk of the phosphate fertilizer so necessary to her great wheat-growing areas from the rich phosphate deposits of North Africa. During that war, Russia was effectively isolated from Mediterranean shipping, and in the last years of the war considerable portions of the Russian population were virtually on a starvation basis, largely because of the reduced crop yields resulting from the lack of phosphates. Accordingly, one of the early developments in the first Soviet five-year plan was a program to discover domestic sources of phosphate.

At that time no high-grade rock phosphate of the type that we know here, or that was available in North Africa, was known in Russia. But in the Kola Peninsula – that far northern projection into the Arctic lying just west of the White Sea – were large bodies of curious rock composed of two otherwise rather rare minerals: apatite, a calcium phosphate; and nepheline, a high-alumina, potassium aluminum silicate.

Up until this time neither mineral had been of any industrial importance. But apatite is a phosphate mineral and with proper treatment it can be converted to the super-phosphate desired by agriculture. This the Russians set out to do, and the building of the Leningrad-Murmansk railroad (so important to the Allies during World War II) was one of the elements in that program.

But to mine this rock, utilize the apatite, and allow the nepheline which constituted nearly 50 percent of the rock to pile up as waste would be highly uneconomic. Soviet scientists recognized that nepheline had qualities which for many purposes made it superior to feldspar in ceramic applications. The result: a new industrial mineral was born out of what had been a museum curiosity.

Next let me turn to an illustration much closer to home.

Sand and clay are important and fortunately rather widespread industrial minerals. Unfortunately, in California, despite our richness in many mineral deposits, sands and clays of industrial quality are all too scarce. Such as do occur are mostly confined to one geological horizon, the very early Tertiary. The Ione formation in the foothills of the Sierras is of this age and locally has produced some good clays, but extensive sections of Ione clay have been regarded as worthless by the ceramic industries because of their high sand content.

Just a few years ago the Gladding McBean Company, one of the principal producers of ceramics on the Pacific Coast, and the Pacific Division of the Owens-Illinois Glass Company jointly undertook a study of portions of the Ione formation with the idea that, by developing suitable extraction techniques, material that had been worthless either as a clay or as a sand could be purified sufficiently to yield both a commercial clay and a commercial glass sand. And just within the past year this has become an accomplished fact.

Everybody wins

One company does the mining; the other one does the beneficiation; Gladding McBean gets the clay; Owens-Illinois gets the glass sand; and the state of California, which collects taxes from both, is happy to see what had been worthless ground turned into a valuable industrial mineral asset.

Besides the tangible profits that are accruing to both companies and to the state, there is important intangible value that develops from an *entente cordiale* between two companies which otherwise might have been competitive. Does it take much imagination to extrapolate such a situation to the case of two countries, which to the advantage of both might share mineral resources and mining techniques rather than hoard them or fight over them?

One more illustration I want to take from California, and once again I wish to review a problem that was of great concern to the United States during the first world war. Phosphorus is not the only important "fertilizer mineral." The big three – as they are sometimes referred to – are phosphorus, nitrogen and potassium. The United States has long been well off in phosphate minerals; nitrogen we can get from the air (as well as from mineral deposits in Chile); but up until World War I we had been dependent on mineral imports from Germany for the potash vital to our agricultural industry. When the body politic gets hurt in the stomach, things are apt to happen! Even so, they happened slowly.

We subsisted – barely subsisted – for a number of years on desperate measures. We dredged kelp off the California coast and burned it, to recover its small yield of potash; we installed the first bag filters on cement kiln stacks, in order to get the potash that was going off in the dust. The American Potash and Chemical Corporation undertook to extract potash from the brines of Searles Lake. (Only later came the discoveries in the Carlsbad area of New Mexico which have so greatly increased our potash production and our potash reserves.)

An extraordinary lake

Searles Lake is no lake in the ordinary sense. In the first place, it is a "dry lake," unique, geologically, in that it consists of a thick body of salts of which NaCl is only one, and among which are a number of otherwise extremely rare minerals – various combinations of Na, K, Mg carbonates and sulphates.

This unique salt body has rather high porosity and the pores are everywhere filled with brine. The American Potash and Chemical Company does not mine the solid salts; it mines the brine – by means of wells and pumps. And from this brine it originally extracted potash and, as an important co-product, boron.

For several years potash salts and borax constituted the products. But in the course of evaporating and crystallizing out these salts from the brine, it became apparent that other products could be obtained by going just a little further in the extractive process. Salt cake (sodium sulphate), soda ash (sodium carbonate), and phosphoric acid have now become important co-products. And – surprising to many – Searles Lake emerged during World War II, just when we needed it most, as our principal producer of lithium.

Bromine salts are also being produced, and only recently we have learned that the Searles Lake brines constitute our nation's greatest reserve of tungsten – something we had thought of as exclusively the property of the hard-rock miner! Tungsten is not now being extracted because at present prices and with presently known methods of extraction, it could not be economically produced.

Glauber salt operations of the American Potash and Chemical Corporation at Searles Lake, California. In winter, when temperatures are sufficiently low, fossil brine is pumped from the crystalline salt body below and sprayed into the air, precipitating Glauber salt, which is "harvested" in spring or summer. In the plant in the background the fossil brine is processed for its yield of potassium salts, borax, sodium carbonate, lithium compounds and other valuable mineral materials.

Not only is Searles Lake a unique mineral deposit; the process of extraction is even more unique. The now successful plant process for the Searles Lake brines is the result of a great deal of painstaking research — research which met the discouragements that research into a new and untried field not uncommonly encounters, but research that today has well demonstrated both its scientific and its economic soundness.

Research in the field of the industrial minerals has been responsible not only for turning worthless rock and fossil brines into ore, and for developing unexpected by-products from sources established for other needs, it has led to synthesis — from easily and abundantly available materials — of industrial minerals of which there is far too scant a natural supply. Take, for example, cryolite (sodium aluminum fluoride)— which is found in only two or three localities in the world, and in only one of these localities does it occur in more than pound lots. In this one occurrence, on the southwest coast of Greenland, it fortunately occurred in millions of tons; for this mineral is the foundation of the aluminum industry.

Cryolite provides the bath in which the far more common, but more refractory ores of aluminum are melted and electrolyzed to yield the metal. Although, in this process, only relatively small amounts of cryolite are consumed, the one natural deposit of this mineral has now been virtually exhausted. Fortunately, synthetic cryolite can now be prepared from other much more abundant and widely distributed minerals.

Diamond is today far more important as an industrial mineral (because of its supreme hardness) than it is as a gem-stone. The United States has always been, and probably always will be, dependent on Angola and South Africa for its supply of natural diamonds. But now, after more than a century of abortive attempts by scientists, engineers, philosophers, frauds and magicians, we at last have a practical method for synthesizing diamonds from that very abundant raw material, coal. Mica, one of the trickiest of all minerals to synthesize, can now be made as the result of patient and imaginative research. And we are thus no longer so dependent upon India and Brazil as we once were for this mineral which throughout the war and for some time after stood practically at the top of the list of critical materials.

As a result of the spectacular development in satellites, moonwatching has become a serious avocation and missilery has become an especially engaging field of science. But I cannot help but feel that with the great hue and cry towards outer space we may be neglecting important exploration that needs to be done beneath our very feet!

Should it be any more intriguing to send recording instruments into the relatively unknown areas just beyond the earth's atmosphere than to send recording instruments down beneath the first of the discontinuities in the earth's structure? The so-called Mohorovicic discontinuity (immediately beneath it we know almost nothing of the underlying material) lies only some 20 miles beneath the continental areas, less than 5 miles beneath the oceans.

We are already conducting mining operations at depths of about two miles, and oil wells have been drilled nearly four miles down. Ten years ago the farthest up we had reached (with a V-2) was a little over 100 miles. Now the U.S. Air Force rocket has gone 79,000 miles! Is any more of a scientific and engineering breakthrough required to go from 100 to 79,000 miles up, than to go from 4 to 20 miles down?

Our artificial satellites are sending back information on temperature, density, and radiation. This is exactly the kind of information that we need from these unknown depths in the earth. Such information would be of intense scientific interest, and it could be of great practical value, for out of it we might learn what triggers earthquakes, how granite is formed and whence the lava is generated that causes volcanoes. Here is research that should be done, and I hope will be done soon.

Mineral policy

But, in the meantime, let us look into the vexing problem of mineral policy. In order that, for the moment at least, I may not incur the wrath of my friends in either the nonmetals or metals industries, I shall take my first illustration of mineral policy from the field of petroleum.

A distinguished petroleum geologist told me a few weeks ago that the "extractive cost" of a barrel of oil at the well head in Saudi Arabia is about a nickel. Here in the United States, it is about a dollar. If Americans, as a nation of automobile users, desired to establish a policy by applying the rule of "the greatest good to the greatest number," it would seem that we should bring in all of that nickel-a-barrel oil that we possibly can and thereby lower the cost of living, or at least the cost of driving, to our benefit. Moreover, in doing this, might we not also enjoy the satisfying feeling that we were at the same time contributing to our national defense?

We have only so much oil in the ground and we have already taken a lot of it out. Producing, as we have for many years, more than half of the world's requirements for petroleum, we now have left only about 15 percent of the Free World's reserves. We might have real trouble in fighting another big war with just the oil still available from domestic sources. Why not, therefore, import all the foreign oil we can and save our own oil for the time when we may desperately need it?

Counterargument

These are telling arguments, but before accepting them at face value, look at the other side of the coin. The domestic petroleum industry is one of our largest and most efficiently functioning industries (as the result of heavy emphasis on research all the way from exploration to production and processing). If nickel-a-barrel oil comes here in large quantities, then large segments of our domestic industry may have to go out of business – industry that is employing thousands of Americans, paying millions of dollars in taxes, and millions of dollars in dividends. Would this be good?

And what of national defense? Just knowing that we have reserves of oil in the ground would do us little good for either an immediate military or industrial effort. We must have equipment installed *and* operating in order to get the oil from the ground, and we must have men familiar with operating that equipment. Obviously we cannot accomplish this by having the oil wells and the petroleum engineers all in Saudi Arabia and Venezuela!

If I have pointed up the problem of petroleum policy it is only because petroleum is a more familiar mineral commodity to most of us than are many of the metallic and the industrial minerals. Many of these, even though our tonnage needs are small as compared to petroleum, are equally vital to our economy. And the problem of supply is more acute for many other minerals than is the supply of petroleum, for a good number of vital minerals are not found in minable concentrations within the United States.

I know there is a general feeling that "if we want some mineral badly enough, we need only raise the price high enough, and we'll get it – from domestic sources." For some things this may well be true, as it was true for magnesium during the war, and more recently, for uranium. But for some things this is just not true – tin for example. The price of tin could be raised to dollars a pound, and the amount of domestic tin ore that would result would be insufficient to supply even a tiny fraction of our needs. So what must we do to get tin? *We must be friends* and *keep* friends with the tin-producing nations. We can do this by reasonable and consistent reciprocal trade agreements; we cannot do this by unilateral deals, by making sudden demands and following these with sudden cutbacks, by forcing feast and then famine upon sister nations.

Whether the problem is one of domestic versus foreign production, or of needed imports, it is clear that there are no easy solutions. Mineral policy right now, and probably for years to come, must be a policy of compromise. Intelligent compromise can only be achieved on the basis of thorough knowledge and understanding. Alas! Geologists and mineralogists do not yet know nearly as much as they would like to know about the ultimate origin or the cause of distribution of ore deposits.

This we do know: Ours is a rather assymetric world, geographically. The rocks that immediately underlie the great ocean basins are basically different from those that immediately underlie the continents. And within the continents there are vast differences in the details of the rocks, and associated mineral deposits. Why was almost all of the world's cryolite concentrated in a few acres of ground at Ivigtut, Greenland? Why is perhaps 90 percent of the world's borax concentrated in southern California?

But while the answers are being sought, we must live with the facts: that no nation is self-sufficient in terms of the mineral resources required for 20th century civilization. Therefore when a nation has 99 percent of this, or 75 percent of that, has not nature herself presented that nation with a trust that is certainly the concern of all the world, and which thus should be treated as a trust by the nation that by accident of geology and geography has been presented with such a treasure? Ideally, yes. But, practically, we still live in an age dominated by the principle of "finders keepers," and if we find something first, it's all ours, to do with just as we very well please.

A way out

Must we always live within the horns of these dilemmas? Must we continue to vacillate between the theoretical logic of "one world" and the free trade principles that this implies, and the practical necessities that seemingly call for high tariffs? Nor is this vacillation any free-swinging pendulum; every time it moves, it generates friction, and generates friction in an environment so tinder-dry that a small spark can start war. Too many wars already have been fought for mineral rights. Must we have more?

There is, I think, a way out. It is probably a slow way out; but I think it is a sure way out. It is likely to be slow for in part it depends on basic research that is still to be done; and the time is as unpredictable as it is for any basic research to reach its objective. And there are many objectives. I will mention only one: *Can we geologists learn successfully to synthesize granite in order that we can better learn how to take it apart?*

"What for?", you may well ask. Well, in the course of fractionation of magma to produce granite, that has gone on in our continental areas, many valuable components have become relatively concentrated in granitic rocks. In 100 tons of average granite there are about 8 tons of aluminum, 5 tons of iron, 3 tons of potassium, 1200 pounds of magnesium, 1200 pounds of titanium, 180 pounds of manganese, 70 pounds of chromium, 40 pounds of nickel, 30 pounds of vanadium, 20 pounds of copper, 10 pounds of tungsten, 4 pounds of lead, as well as significant amounts of boron, lithium, etc.

This is all very fine, you will say, but most of these elements are "locked up" in the form of silicate minerals which are difficult chemically and expensive economically to decompose into their constituents. Quite so. But an average granite also contains about 12 parts per million of thorium and 4 ppm of uranium. These 16 ppm of radioactive elements in 100 tons of granite represent the fuel equivalent of 4500 tons of coal.

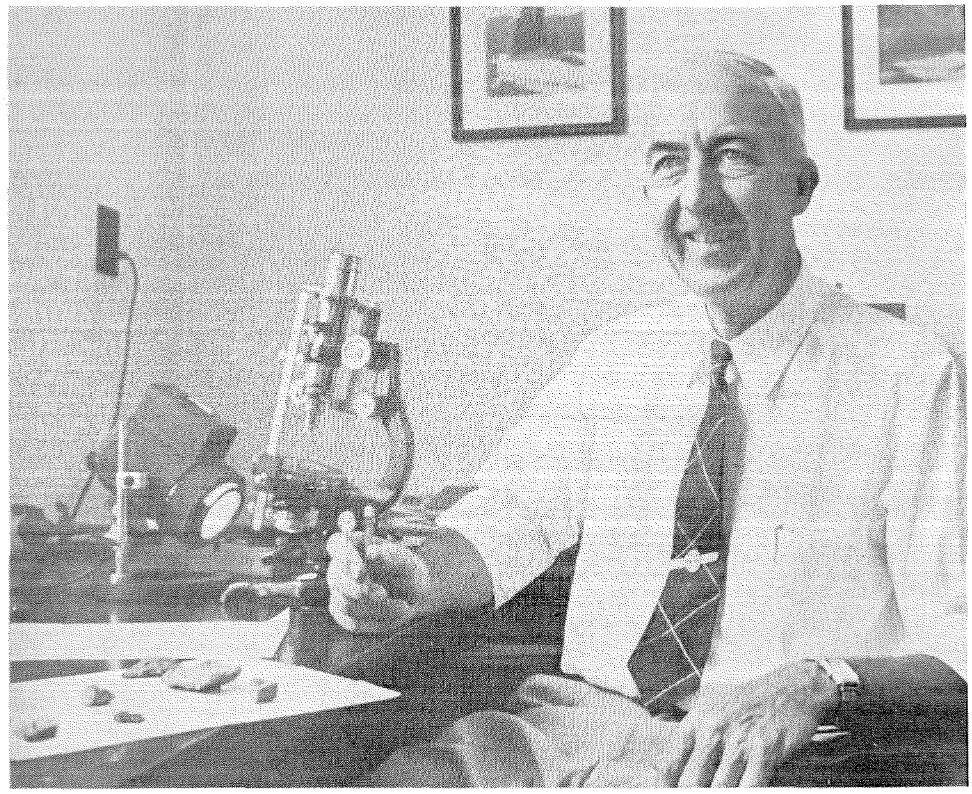
Furthermore, the thorium and uranium, recent research has shown, are not locked up wholly in refractory minerals; a large share is in rather easily extractable form. It seems not unlikely that more than enough nuclear fuel can be obtained from granite to furnish the energy required for its own recovery plus enough surplus to accomplish the extraction of many of the valuable elements cited above.

Inexhaustible mineral resource

When this is done, we may have achieved the nearest approach to perpetual motion that the world has yet seen, *and* we will have a virtually inexhaustible and widely distributed mineral resource, granite, to draw upon. To be sure, this is some distance in the future. We are not yet at the stage of considering nuclear fuel as economically competitive with other sources.

But when the time arrives that nuclear fuel can undercut conventional sources, then we are going to see such demands for thorium and uranium as are rapidly going to exhaust our presently known high-grade ores. Granite will be a next logical source, and the mining of granite for its nuclear fuel thus opens up tremendous vistas for by-products and co-products.

Another virtually inexhaustible resource is already producing minerals for us: the ocean – the "mineral sump" for all of the continents. Long ago, when gold was more sought after than now, we were sometimes dazzled by the figures quoted of the "jillions" of dollars of gold stored in the oceans. And it was true that in a few areas, the concentration of gold in sea



Ian Campbell, professor of geology and executive officer of the Division of Geological Sciences at Caltech.

water was not far below the point where it might be extracted at a profit. If the price of gold should ever go, as once it did on the black market, to $90 an ounce, I daresay someone might start a successful gold mining operation in the seas off the coast of Australia!

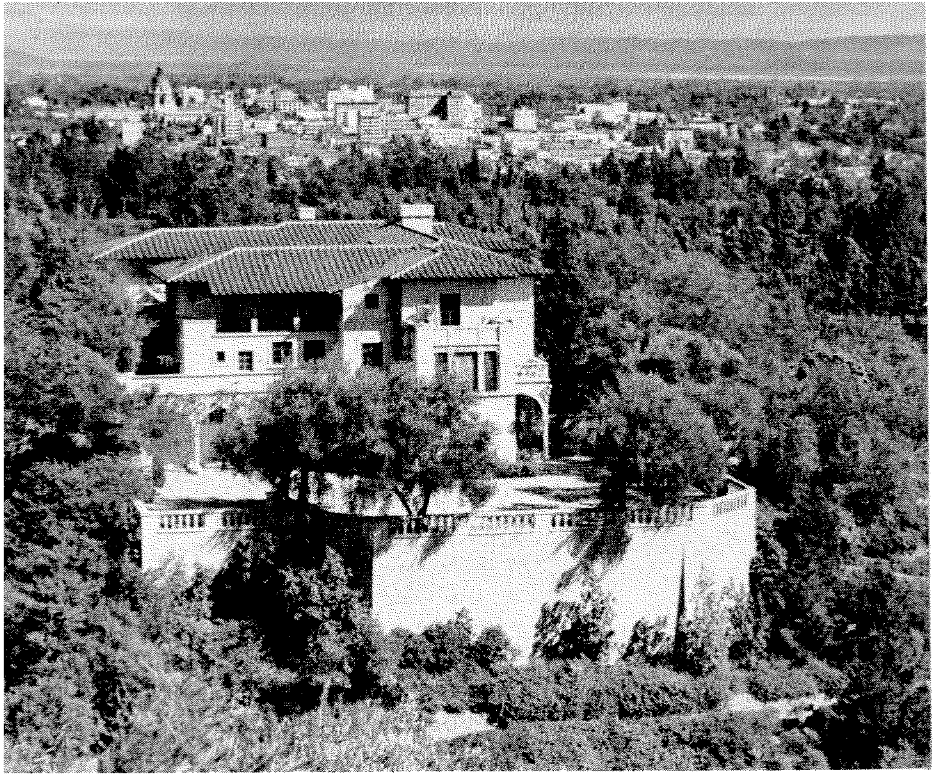
Much more important to us today than gold, and a much more realistic example of what is already being done to make the seas productive, mineral-wise, is magnesium. For a number of years the Dow Chemical Company (in Freeport, Texas), and the Northwest Magnesite Company (at Cape May, Virginia), and the Kaiser Aluminum & Chemical Corporation at Moss Landing, California, have successfully been extracting magnesium salts from sea water – so successfully, indeed, that "synthetic" or sea-water magnesia, has now to a considerable extent replaced magnesite mined from our continental deposits.

Many other valuable constituents are present in sea water, and some day will be forthcoming as co-products or by-products of magnesia.

Trends in the industrial mineral field are pointing the way which soon may be followed by the entire mineral industry. In the past, prospector and producer alike sought the rare and high-grade mineral deposit. Today the prospectors and producers of industrial minerals have successfully shown that the most effective mineral supply is best obtained from large, low-grade, and widely distributed deposits. This development has been made possible by research which has developed by-products and co-products from complex low-grade sources and by research which has made possible synthesis of rare minerals from common materials. Mineral policy, meantime, has of necessity been founded on the unhappy fact that the high-grade mineral deposits – the deposits upon which we have largely built our industrial civilization – are distributed according to what might be regarded as accidents of geology, of geography, and of history. With such distribution it is inevitable that mineral policy could never be entirely satisfactory nor wholly consistent.

Now, by prosecuting research with sufficient vigor, we can look forward to the time when virtually all of our mineral needs, including fuels, can be obtained from two virtually inexhaustible resources: granite batholiths and ocean water. Almost all nations have access to the sea; almost all nations have granite cropping out within their borders, or present at no great depth beneath the surface veneer of sediments. Thus almost all nations will have ready at hand those mineral raw materials which, because of scarcity, have been the source of so much conflict and so much unhappy compromise in the field of mineral policy.

To speed this day we must vigorously prosecute mineral research, This is a job not only for the geologist and mineralogist, but for the engineering scientist, the physicist, the chemist and – recognizing that some of our most important mineral deposits are directly or indirectly the results of organic activity – the biologist. As scientists we can give our research no finer goal. For, when successful, we will have eliminated one of the major causes of war. For the present, however, mineral policy must be compounded out of knowledge and tolerance, and a recognition of the need for intelligent compromise.

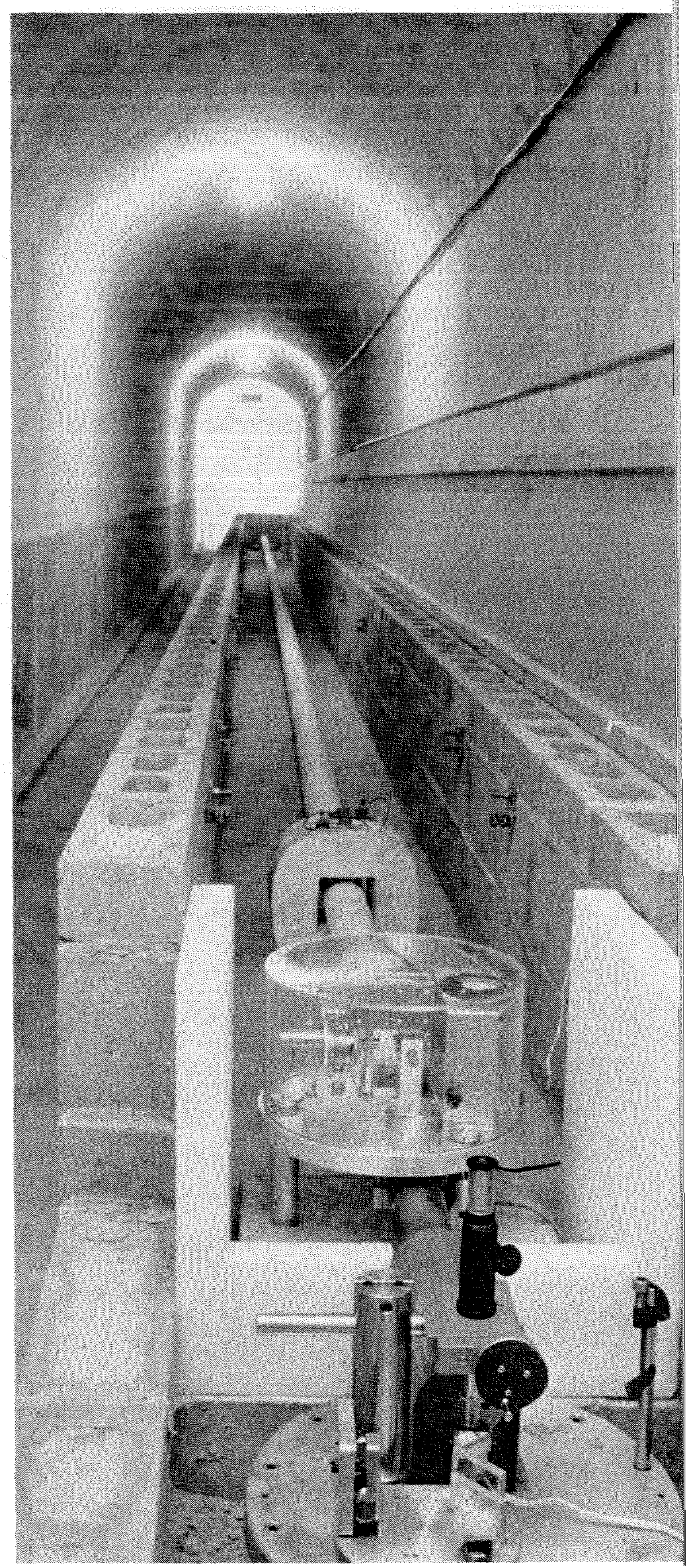


Caltech's Reuben H. Donnelley Seismological Laboratory, which is located in the San Rafael Hills just across the street from the original laboratory, was once the $300,000 Thorsen mansion.

Caltech's New Seismological Laboratory

The impressive entrance hall of the new Laboratory.

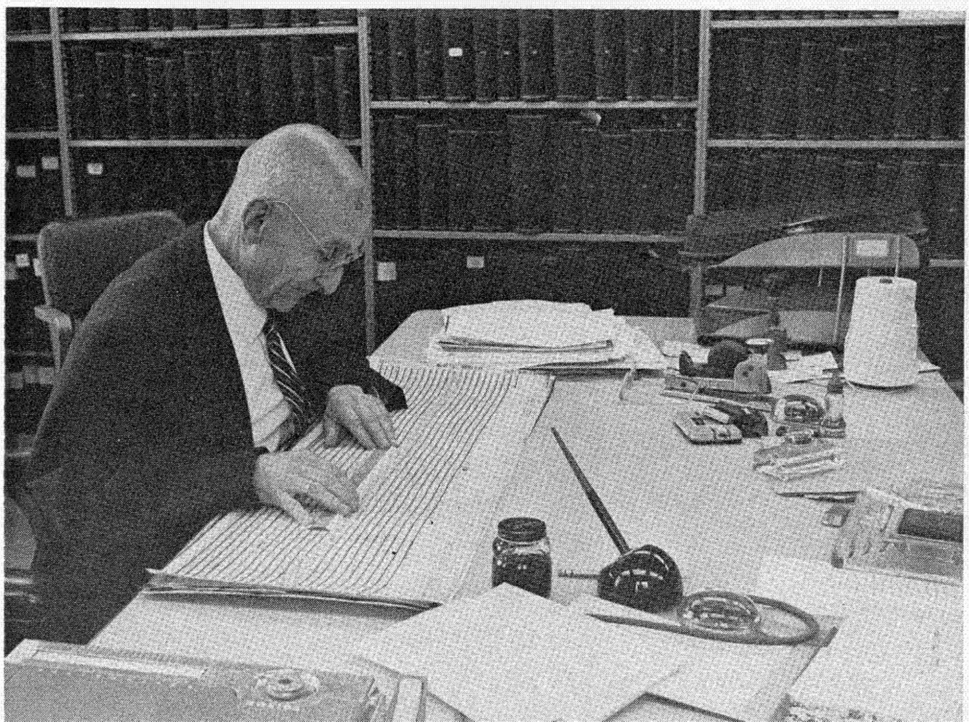
The new Reuben H. Donnelley Seismological Laboratory in Pasadena began operations last summer without the fanfare of a formal opening. Seismologists and staff quietly moved their equipment into the marbled halls of the $300,000 mansion which once was the home of A. C. Thorsen, one of the founders of the Walgreen drug store chain. The building proved to be one of the finest sites in California for the installation of seismological instruments because it is built on solid granitic rock. As a dividend, the property contains a 160-foot tunnel which bores through granite — the ideal site for an east-west strain seismograph. The original Seismological Laboratory, across the street from the new one, is still in use but has been renamed the Kresge Laboratory. The Lab was founded in 1926 as a cooperative venture of the Carnegie Institution of Washington and Caltech but is now completely a Caltech operation and in the past 32 years has developed into one of the world's leading centers for earthquake research. Funds for the purchase and remodeling of the Thorsen estate were provided by Mr. and Mrs. C. Pardee Erdman, The Kresge Foundation and The James Irvine Foundation. The new Laboratory was named in honor of Mrs. Erdman's father.



This 160-foot tunnel, bored through solid granitic rock, was originally built for easy access to the gardens but now houses the east-west strain seismograph.

Frank Press, professor of geophysics and director of the Seismological Laboratory, is noted for his geophysical investigations of the crustal structure of the continents and ocean basins, and for his theoretical and experimental work on elastic wave propagation.

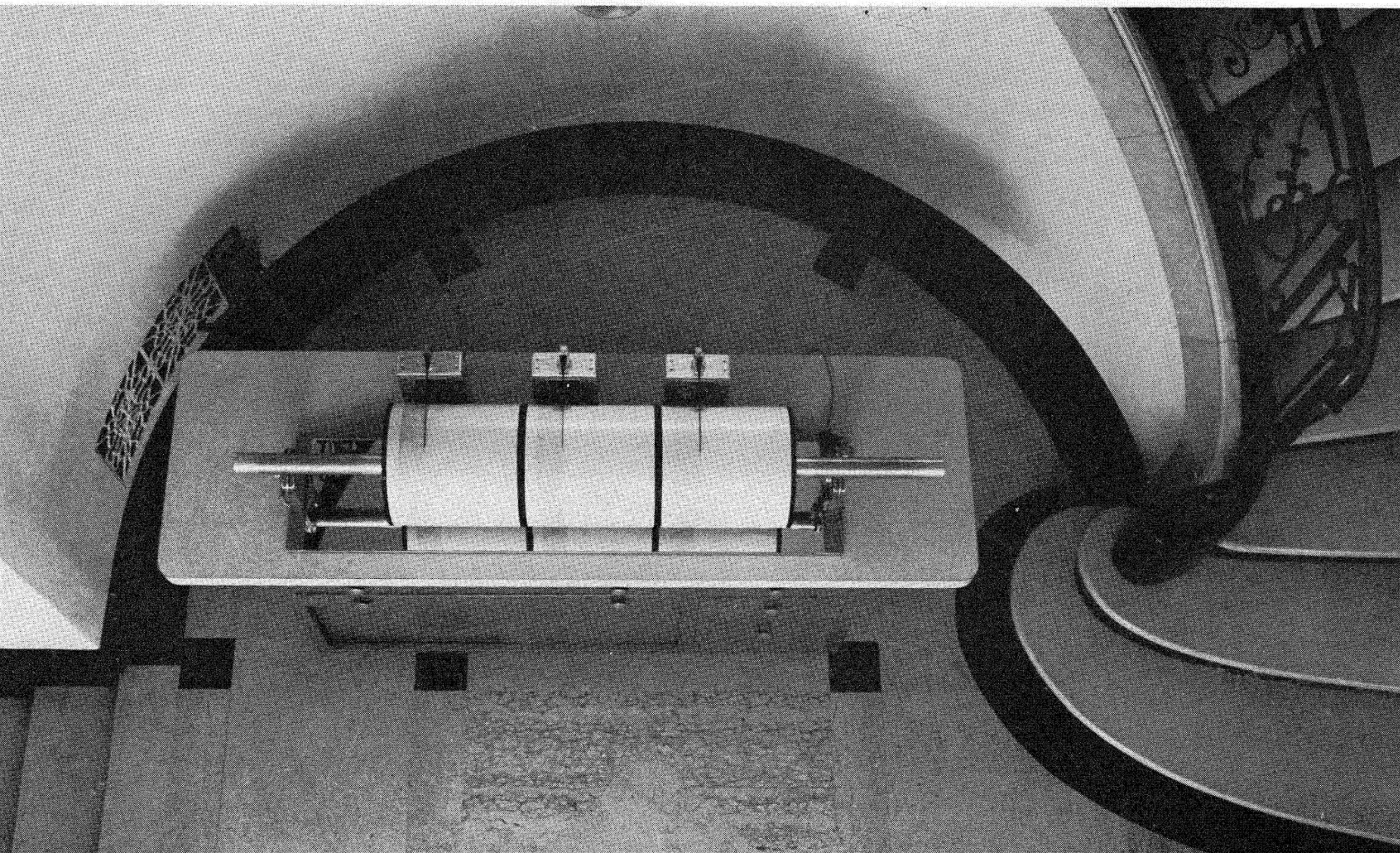
Charles Richter, professor of seismology, and originator of the earthquake magnitude scale, is supervisor of seismogram measuring and interpretation at the Lab.



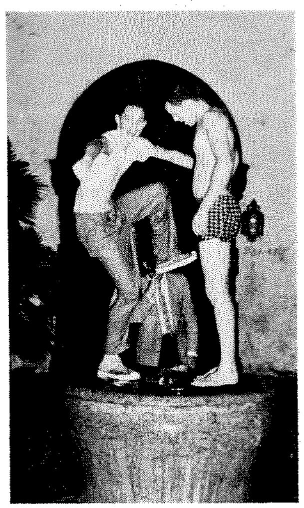
Beno Gutenberg, professor of seismology, and director of the Lab from 1947 through 1956, is an authority on the investigation of seismic waves and on structural differences between continents and ocean bottoms.

Hugo Benioff, professor of seismology, and the developer and builder of the secular linear strain seismograph, used for earthquake measurements all over the world.

The Lab's three ink-writing recorders occupy a prominent position in the main hallway. These seismographs are used for quick consultation as soon as earthquakes occur.



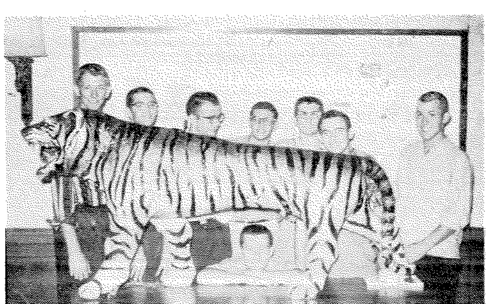
Frosh, Frenzy and Ferlinghetti



It's October again and life at the Institute begins with a bang. Rotation time – but I'm on the other side of the fence. I neglect to shave for a few days, put on my beret, take my copy of Pound's *Selected Poems* and sit in the lounge impressing frosh by discussing existential psychoanalysis. ("We're a well-rounded house, you know.") Duly convinced, the poor fellows wander back to their rooms and tell their friends about the weirdie who sits in Ricketts lounge discussing existential psychoanalysis, and who knows but *nothing* about vector relations in an n-dimensional space. ("They're not as well-rounded as they say they are.") Frustrated, I go back to *my* room and play solitaire.

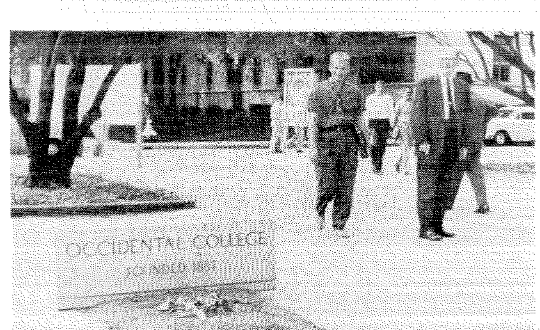
This, however, is not the end of my efforts. I collect some new frosh and off to the Unicorn we go. Here we sit in the doorway discussing Ferlinghetti ("Like, what's Ferlinghetti, man? I don't follow you?") and making faces at the Sunset Boulevard Mafia. (Oxy men trying to look like touts, but too well-fed to create the illusion.) These are golden days and after the normal grind starts churning along its way I remember them with regret, apologizing for their evanescence.

Finally the end approaches; the freshmen commit. (My score: 90 percent missed. There will be other years.) It is Initiation time.



I can truly say that I enjoy Initiation. All one has to do is sit and laugh and occasionally pour water on the chair in which some poor frosh is about to sit. This year's crop have plenty of fun. They push an eight-foot push-ball all the way through downtown Pasadena and finally roll it off the top of Bullocks' three-story parking lot. They steal a gravestone inscribed: *Occidental College, Founded 1887*, and also various other articles of little intrinsic value such as a moth-eaten tiger and a statue of the Big Boy from Bob's Restaurant. (For the latter they demand a ransom of its weight in hamburgers.)

It is a gentle Initiation. The Caltech Student House Food Party plot is nipped in the bud by alert members of the Board of Control. The Ricketts frosh



create a little good will by helping out for an afternoon at an orphan's home. Finally, all the pledgemasters are soaked in the final act of Initiation. It is Over, and now I can have no reason for avoiding the textbooks. Alas! Poor Techman. I knew him well. A fellow with infinite leisure hours, put to no good use but the getting of dates from Los Angeles County Hospital, and the construction of a new and mightier water-balloon catapult which hurls a missile a quarter of a mile.

There are the usual complaints from the pledges:

"Man, when my gang in New York had an initiation, we didn't mess around like this, we GAVE it to 'em. We beat 'em to a pulp."

"Gee, you guys are tough. You don't take nothin'. Hey, Efron, loan me ten bucks so I can go out with that girl friend of yours."

"I can't study! That's right. I tell you I can't study – Where're we going Friday night, honey?"

There are a whole new crop of intellectuals–quasi, pseudo, and otherwise:

"Who's Kerouac?"

"This Pound is SO STIMULATING!"

"What do you know about Rimbaud?"

"DuBridge? DuBridge? Oh, yeah! The Sanitary Engineer."

The receptions go on as usual. The proud vain men of science meet the blushing architects of the future:

"Hello, boys. My name is Linus Pauling. I'm a chemist."

The new class contains the usual ultra-conservatives:

"I tell you Edison didn't invent the light bulb! It was Straichnitoff. I read it in the *Daily Worker*."

"Gentlemen, I have called you here so that we might approach a common purpose, an end toward which we can bend our collective might. Let us resist initiation and rotation actively and passively. In doing so we will assure the intellectual future of coming generations of Caltech freshmen."

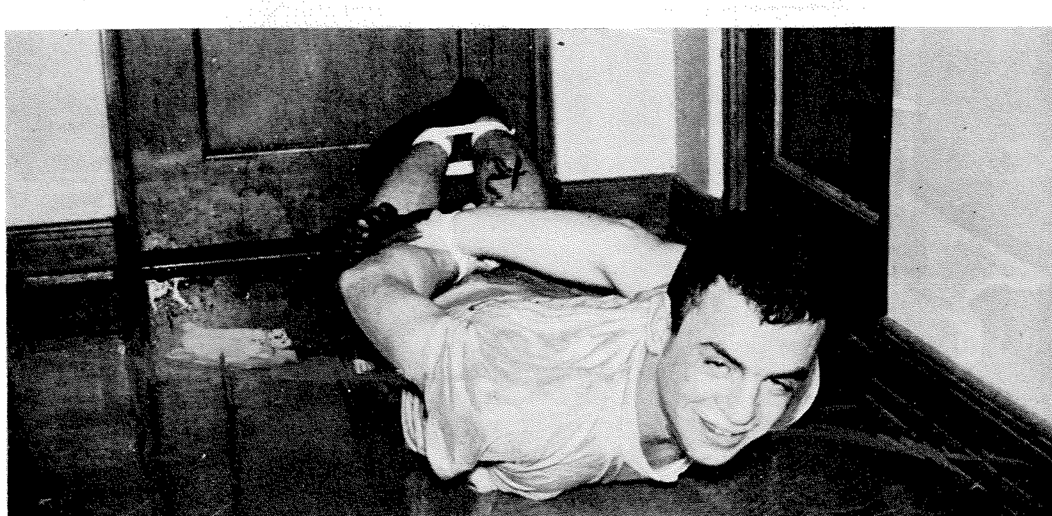
"Let's have a House *Ulysses*-reading party!"

But off I go to class, whistling happily, ready to do some serious thinking. In Physics I think of Jean (Stanford); in Geology, Maryanne (Scripps); and in History, Ophelia (Hamlet). I daydream my way through Vector Analysis, Sartre, elementary circuit theory, commutative rings, and quantum mechanics. Between visits to the school psychiatrist I indulge in deep introspection and deeper strawberry sundaes. I begin work on my new novel, "The Age of the Misanthrope," a psychological study of nuclear physics. The first paragraph is thrown away thirty-three times before I am satisfied. My volume of forty collected poems, of which three are finished and one is on the way, lies on my desk forgotten.

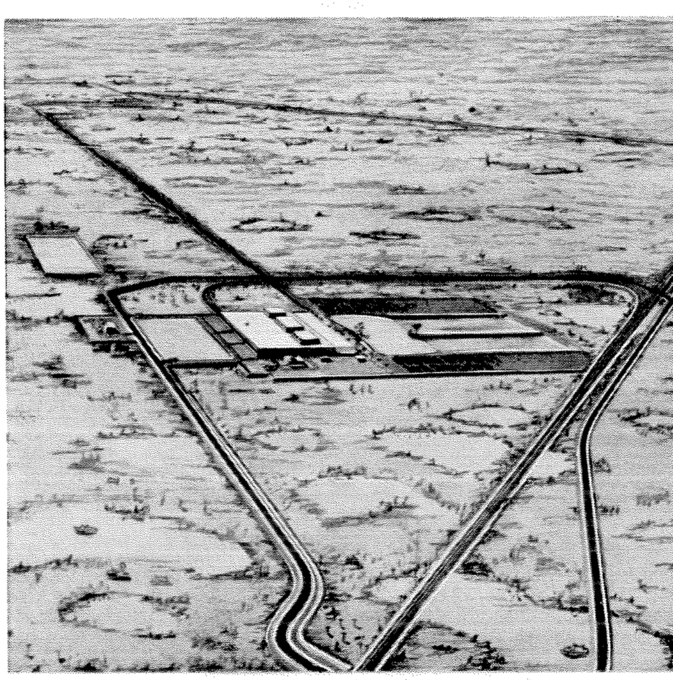
The end of Rotation and Initiation signals the start of Caltech social life. Once again I begin my fruitless quest for the Ideal Woman. (Five-feet-nine inches tall, red hair eleven-and-one-half inches long, a beautiful face, green eyes, perhaps blue–I'm not stuffy – measurements: 38-24-37, an intense interest in poetry, physics, philosophy, and existentialist literature.) Unfortunately it always turns out that the Ideal Woman does not go to high schools around and about or to Occidental, USC, Scripps, Pomona, Harvey Mudd, or UCLA. I'm saved for the time being, but still frustrated. College is merely the battleground on which one fights the problem of Woman. One has no possibility of winning. The end is merely marriage – either that or eternal melancholia; and Woman is the lesser of the evils, saith the Prophet.

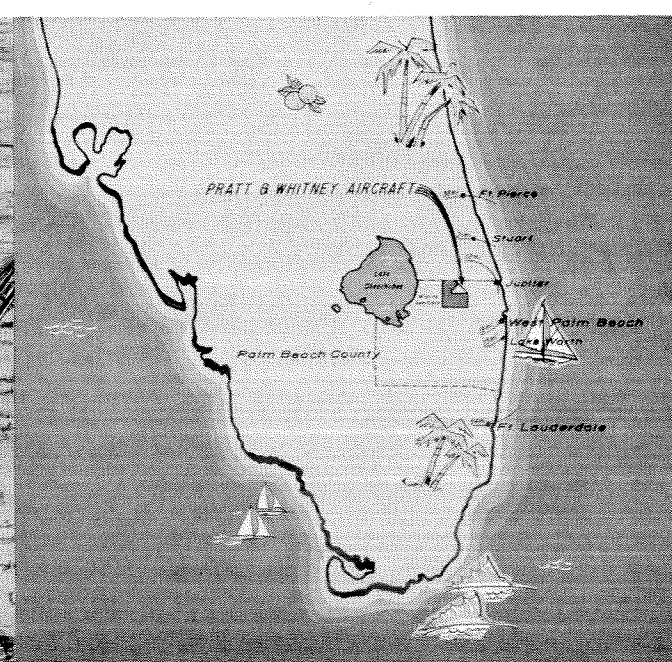
Yes, here it is October once more, and in Dabney and Blacker and Throop and Fleming and Ricketts we sit and discuss our schemes for getting rich, finding women, unearthing the nature of the universe, remodeling the Institute; we write for the paper and do our homework in Physics 1, History 2, Math 108, English 7; we spend our time belaboring time, and all for a purpose unbeknownst to most: we will bring the mountain to Mohammed (or is it Millikan?) and we will do it with nuclear power.

–Joel Yellin, '61



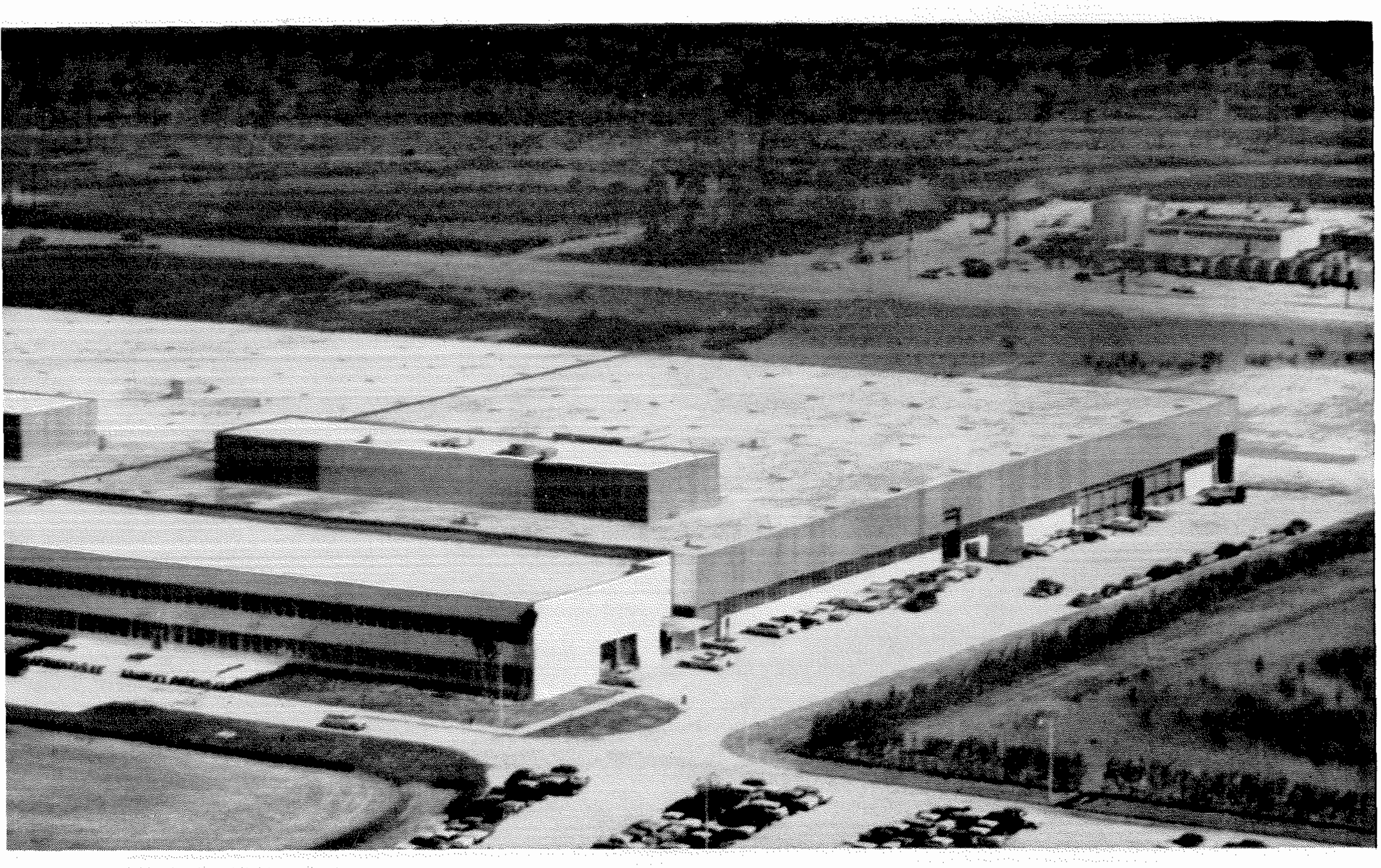
FLORIDA RESEARCH AND





ISOLATION—Ten square miles comprise the site of Pratt & Whitney Aircraft's new Florida Research and Development Center. Experimental shops and offices covering some 17 acres are in the foreground, while the tests areas, barely visible in upper left, lie four miles in the background.

LOCATION—The new Center is located at United, Florida, midway between West Palm Beach and Lake Okeechobee, in the upper Everglades area. It is almost surrounded by a wildlife sanctuary. Most employees live in the cities and towns along the east coast of Florida, driving to the Center on excellent new highways.



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To probe the propulsion future . . . and to build and test greatly advanced propulsion systems for coming generations of flight vehicles, Pratt & Whitney Aircraft is now operating its new Florida Research and Development Center. This facility supplements Pratt & Whitney's main research and development installations in Connecticut.

The new Florida Center, financed and built by Pratt & Whitney Aircraft, is unique in America's air industry. Here a completely air-conditioned plant with 17 acres under roof is specially designed and equipped for the development of new power plants of virtually any type. Testing is handled in special isolated areas; the nearest is four miles from the plant and many miles from any inhabited area. The new Center can be greatly expanded on its 10-square-mile site. Continued isolation is insured by a vast wildlife sanctuary in which the Center is located.

Of the many people employed at the Center today, about half are scientists, engineers and highly trained technicians. By late next year, the total number is expected to be almost doubled.

The new Florida Research and Development Center is one more reason why Pratt & Whitney Aircraft is able to continue producing the world's best aircraft propulsion systems . . . in whatever form they take.

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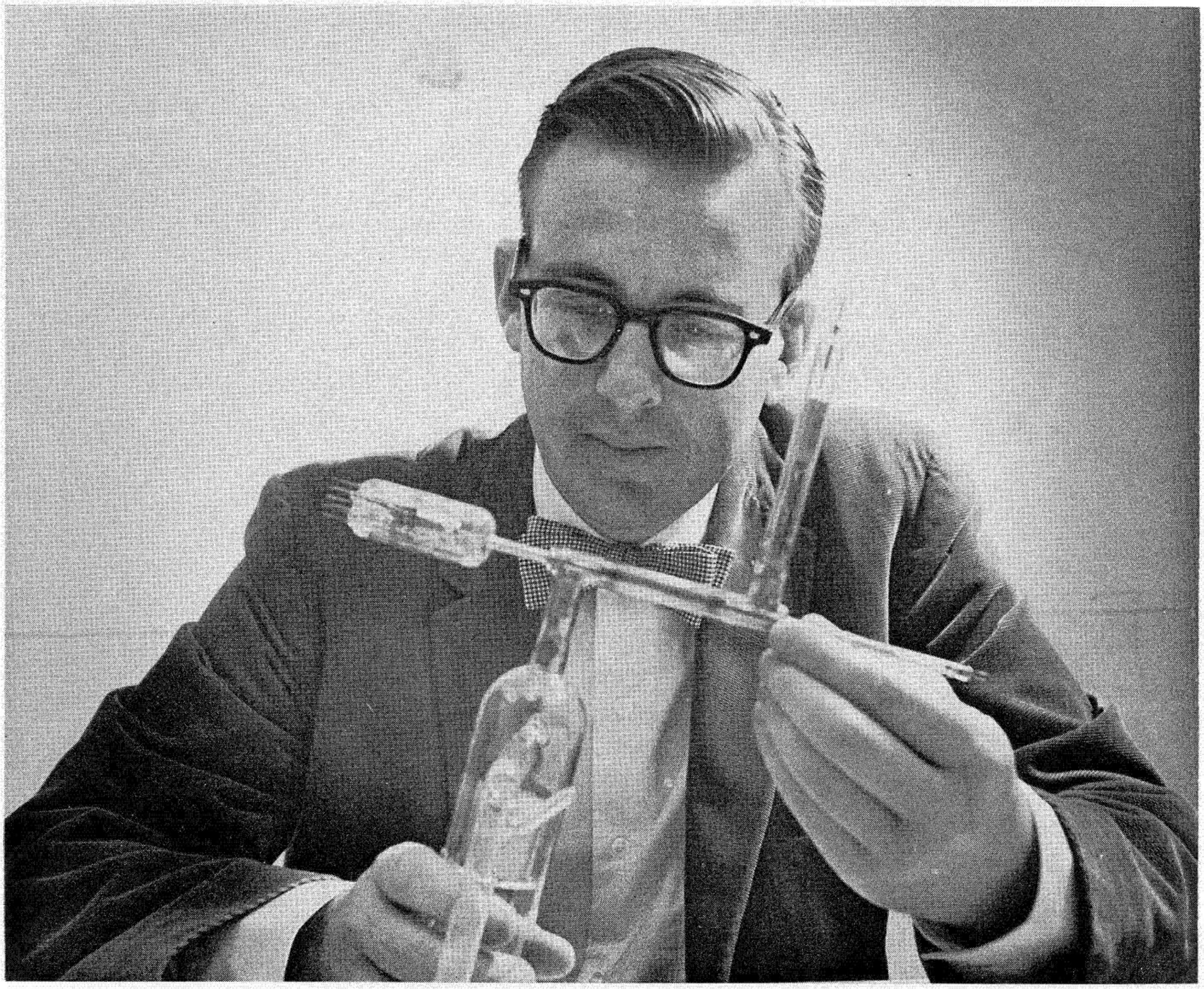


Plasmas are harnessed for research in amplifier held by Roy Gould, associate professor of electrical engineering.

Plasma — The Fourth State of Matter

by Gary Boyd

On our earth, we are accustomed to dealing with matter in just three states — solid, liquid and gas. Yet a fourth state exists called plasma. A plasma is formed when a gas is raised to such a high temperature that its atoms come apart, forming a neutral mixture of positive ions and electrons.

The corona of the sun is a good example of a plasma, as is the ionized gas found in fluorescent light bulbs and mercury arc street lamps.

The new and exciting field of radio astronomy is concerned with the radio frequency phenomena found in the combination of research by astronomers on the swirling masses of ionized gases or plasmas in the heavens, and by engineers on the propagation of radio waves through the ionosphere.

Plasmas are also playing a fundamental part in the experimental fusion machines which may eventually harness the power of the H-bomb for peaceful purposes.

Even in the field of aeronautics, engineers are studying plasmas for a clue to solving the problems of re-entry to the earth's atmosphere at the high velocities of intercontinental ballistic missiles.

A plasma has a finite electrical conductivity due to collisions of electrons and ions with the un-ionized gas molecules. The electrons and ions are in continuous milling motion due to the random distribution of their thermal energies — just like the molecules of an un-ionized gas such as air.

Plasma oscillations

A plasma medium is capable of plasma oscillations. Such oscillations result from a displacement of a group of electrons from their equilibrium position. Since the ions in the plasma are much more massive than the electrons, the ions tend to be relatively fixed in position. Therefore a local displacement of a group of electrons leaves an excess of positive charge (ions) which exerts an attractive force to return the electrons to their equilibrium position. Such a force imparts energy to the group of electrons and they tend to overshoot their equilibrium position and thus oscillate about it.

This natural resonance or plasma oscillation frequency of the electrons is proportional to the square root of the electron density in the plasma. In some respects these plasma oscillations can be likened to the shaking of a bowl of jelly. In electric arc discharges made in the laboratory, such oscillation frequencies are often in the microwave region of 1,000 megacycles per second. In the solar corona they are in the range of 10 to 1,000 megacycles.

Plasma oscillations can be caused by a radio wave passing through the medium. When one is considering experiments such as the interaction of radio waves with plasmas it is possible to show that the effect of such a plasma is mathematically equivalent to a charge-free medium with a dielectric constant different from free space. Of course, the index of refraction of a material is proportional to the square root of the dielectric constant.

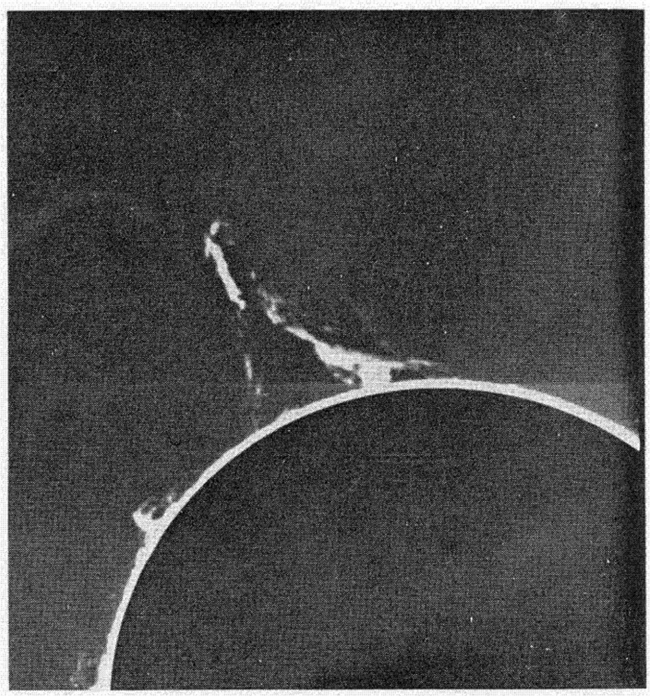
All such known dielectric mediums as glass, water, diamond, ceramic, plastic and the like have relative dielectric constants several times that of free space. None have dielectric constants less than the free space value. A plasma, however, has a relative dielectric constant which is always less than unity and may even become negative if the plasma oscillation frequency exceeds the frequency of the radio wave in the medium. Radio waves traveling in a medium of positive dielectric are reflected at the interface with a medium of negative dielectric.

On the basis of this description of a plasma we are able to appreciate the relationship between plasma physics and the propagation of radio waves through the ionosphere. The ionosphere is actually just another example of a plasma. The theory of radio wave propagation through the ionosphere is complicated, however, by the effects of the earth's magnetic field on the dielectric properties of the ionosphere. The magnetic field causes the dielectric constant to be anisotropic — meaning that the dielectric constant differs in different directions.

In the electrical engineering laboratories at Caltech, engineers are investigating radio frequency phenomena with an electron tube called a plasma amplifier. This tube sends a modulated electron beam through the plasma of an electric arc discharge. If the natural plasma oscillation frequency corresponds to the modulation frequency on the electron beam, then upon demodulating the electron beam one finds that the output signal is larger than the input signal and thus amplification has resulted.

The interest of astronomers and engineers in radio astronomy has led to intensive study of the properties of plasmas. As all of us are aware, many heavenly bodies emit electromagnetic energy in the visible light frequency range. Many also emit energy in the radio frequency range. In the past decade, considerable attention has been devoted to theories concerning the means of generation of radio frequency energy in heavenly bodies such as our own sun.

As research with Caltech's plasma amplifier indicates, there is a possible mechanism in the corona of the sun and like bodies for the amplification of radio frequency energy. If a solar eruption sends a high velocity stream of electrons through the sun's corona, we then have a situation capable of amplifying stray signals on the stream. Such amplification



Solar eruptions are one source of the radio frequency energy studied by radio astronomers. This June 15 eruption reached the greatest height (850,000 miles) observed from Mount Wilson Observatory since 1946.

occurs at frequencies close to the natural plasma oscillation frequency of the corona. If such energy is radiated into space we might well receive some of it on earth. Of course, there are probably many other sources of radio frequency energy in the heavens.

Other researches in these laboratories on the interaction of microwaves and electron beams with plasmas are concerned with the investigation of the propagation of newly discovered waves on plasma columns. The interaction of electron beams with such waves is interesting since these waves travel at velocities which are small compared to the velocity of light. This means that they can be made synchronous with the electron beam velocity. Also of interest is the use of microwaves as a means of measuring plasma densities and temperatures. Such measurements are particularly important in fusion research.

Controlled H-bomb

Certainly the largest effort today in the field of plasma research is concerned with fusion containment. This is often referred to as the controlled H-bomb. Fusion in this sense means the fusion of two hydrogen ions (normally the heavy isotopes deuterium or tritium) to form a helium ion with the release of a large amount of energy. Since the hydrogen atom has only one electron, its ion is just the nucleus.

In order for two colliding deuteron nuclei to fuse and form helium it is necessary that they collide at a very high velocity. The temperature of the deuteron nuclei must be about 350 million degrees Centigrade, (corresponding to 30,000 electron volts of kinetic energy) for such a process to be self-sustaining and thus produce more energy than it loses to its surroundings. This amount of energy is small compared with the millions of electron volts and in some cases even the billion electron volts of energy supplied to particles in modern particle accelerators, but it is large in the sense that a comparatively large number of particles must be accelerated to this average kinetic energy.

Present efforts at controlled fusion deal with low density deuterium gas which is ionized in some manner to form a plasma. This plasma is contained in a strong magnetic field or magnetic "bottle." An electric discharge formed in such a gas will contain deuterium nuclei with an average random energy of only a few electron volts. It is then necessary to pump energy into this plasma system in some way to raise the average energy of the deuterium nuclei up to approximately 30,000 electron volts. At the present time energies of only 430 electron volts (5 million degrees) or so have been obtained, and then only for a thousandth of a second.

There are several methods of feeding energy into a plasma. One that is widely used is to pass an electric current through a plasma. This heats up the plasma due to the collisional losses of the charged particles with neutral atoms. A second is to use the pinch effect. This method receives its name from the fact that a high current electric arc discharge in an ionized gas will constrict due to its self-magnetic field. As the arc constricts, the average energy of the plasma electrons and ions increases. The third is the magnetic pump, in which the confining magnetic flux is periodically increased and decreased. This will induce a circumferential electric field which acts on the charged particles and heats the plasma.

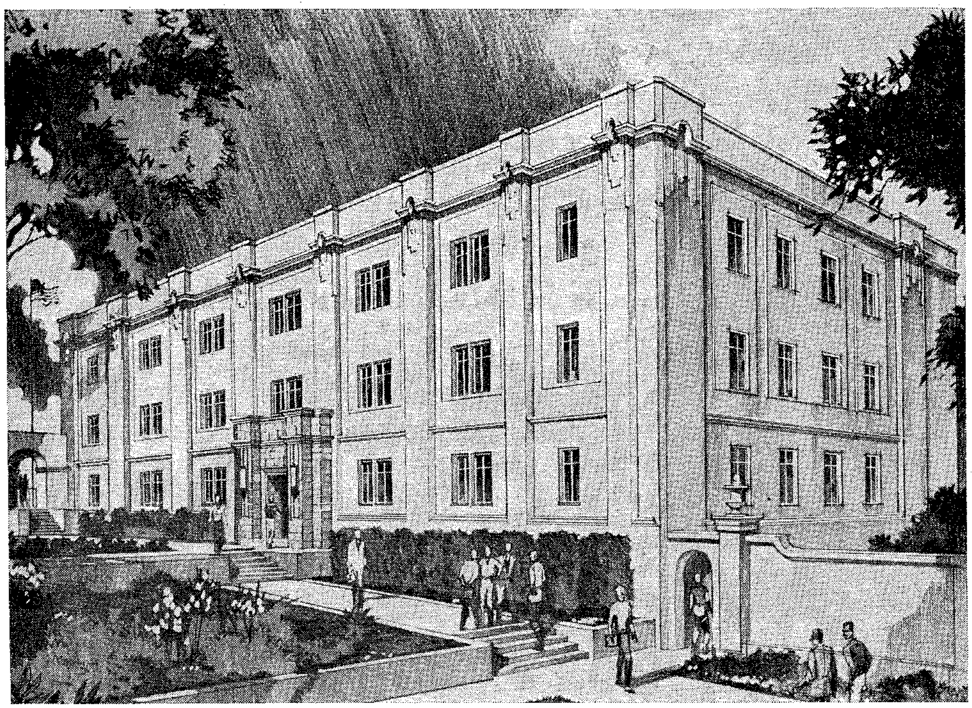
Ballistic missiles

Another field of interest to plasma research is concerned with missile re-entry problems. When an intercontinental ballistic missile re-enters the earth's atmosphere at approximately 15,000 miles per hour, the velocity is high enough so that a collision of an atom of the atmosphere with the nose of the missile is sufficient to ionize the atom. Thus it might be expected that around the nose of such a missile an ionized gas shock wave will exist — the medium we have now learned to call a plasma.

As a plasma is a dielectric medium because of its radio frequency properties, we immediately face problems relating to the effect of this medium on radar frequency waves that might be sent up to detect the arrival of such a missile. Would it make the missile easier or more difficult to detect? Also, if we remember that a plasma is capable of natural oscillations, the interesting possibility occurs that if this oscillating plasma radiates any of its radio frequency energy, then perhaps this could be detected on the ground by a radio receiver. In other words, will a re-entering missile cause plasma oscillations that can be detected from the ground without the aid of a radar frequency transmitter?

Aside from problems associated with the detection of high speed missiles re-entering the atmosphere, there is the problem of communicating with high speed missiles which are surrounded by this plasma dielectric. If the natural plasma oscillation frequency is greater than the frequency of the incident wave, the dielectric constant becomes negative and the medium will no longer propagate such a radio wave. For similar reasons the antenna radiation pattern of a missile is modified by the rocket flame resulting from turning on the rocket engine.

Another important field of study in plasmas is ion propulsion, a form of propulsion in which a cloud of charged particles, rather than hot expanding gases, is forced out of the rocket engine. Plasmas are also being used to obtain temperatures as high as 15,000° Centigrade for high temperature research (the temperature limit of chemical fuels is approximately 6,000° Centigrade). These are only a few of the many applications found in current plasma research. The future may bring still unimagined opportunities for research in this new frontier of science and engineering.



Architect's drawing of the new Alfred P. Sloan Laboratory of Mathematics and Physics.

The Month at Caltech

Sloan Laboratory

A new mathematics and physics building on the campus has now been assured by a grant of $1,165,700 from the Alfred P. Sloan Foundation of New York. The gift brings total contributions to Caltech's $16,100,000 Development Program to more than $7,000,000. Seven of the 15 new buildings in the program are now assured by specific gifts.

The Sloan gift will be used to finance construction of the new mathematics and physics facilities within the building which for many years has housed Caltech's high voltage laboratory. This will become a modern five-story structure (two stories below ground) with nearly 50,000 square feet of floor space, and will be renamed the Alfred P. Sloan Laboratory of Mathematics and Physics.

The three upper floors of the building will contain offices for faculty members and graduate students in mathematics, as well as conference and seminar rooms, a lecture hall and a library.

The lower floors will be devoted to facilities for two experimental physics programs. To expand its research on the nuclear reactions of light elements, Caltech will install in this space a new 10-million-volt Van de Graaff accelerator, which is being supplied by the Office of Naval Research at a cost of $1,000,000.

New facilities will also be provided for research in the field of cryogenics, or low-temperature physics. Caltech has made important contributions to the study of the behavior of liquid helium at temperatures within a few thousandths of a degree of absolute zero. It is now expanding this work to embrace studies of the low-temperature phenomenon known as super-conductivity, in which the resistance of certain materials to electrical current disappears.

The Next Hundred Years

Caltech launched a 13-week television series this month, designed to give audiences a look at some of its research and teaching activities.

The weekly series, entitled "The Next Hundred Years," features Caltech scientists demonstrating and describing their current investigations. The programs are being presented as a public service by KRCA-Channel 4 and the National Broadcasting Company. They are shown in the southern California area on

Channel 4, Saturday evenings at 6 p.m.

The first program, on November 1, with an introduction to the series by President DuBridge, featured Harrison Brown, professor of geochemistry (whose book, *The Next Hundred Years*, written in collaboration with James Bonner and John Weir, gives the title to the television project). In "The Story of the Irish Potato" Dr. Brown described the situation in Ireland in the last century as being analogous to that of the present day, when our civilization is almost completely dependent on science and technology.

Ray Owen, professor of biology, appeared on the November 8 program, "Facts for a Friendly Frankenstein," in which he discussed skin grafting and tissue transplanation, with particular attention to the life-saving effects of bone marrow transplant after exposure to high dosages of radiation.

In "Geological Russian Roulette," scheduled for November 15, Richard Jahns, professor of geology, will tell some of the problems and pitfalls of building and maintaining residence in southern California, keeping in mind the general history of geologic processes such as erosion, faulting and disposition of sediments.

On November 22, Kent Clark, associate professor of English, author of the new historical novel *The King's Agent* – and the only non-scientist to take part in this series – will present "They'll Remember Grandma." In this program he will look at the year 1958 through the eyes of a historian of 2058.

William Fowler, professor of physics, is scheduled to talk on "In the Beginning Was Hydrogen" on the November 29 program – a discussion of the creation of the elements in stars.

Faculty on Tour

Robert F. Bacher, chairman of the division of physics, mathematics and astronomy, left last month for Geneva, Switzerland, for the resumption of international talks on banning nuclear tests.

Dr. Bacher, a member of President Eisenhower's Science Advisory Committee and a former member of the Atomic Energy Commission, is serving as science adviser to Ambassador James J. Wadsworth, deputy UN representative who heads the United States delegation.

Dr. Bacher was a member of the international group of scientists that met in Geneva last summer to work out technical problems involving an international inspection program so that a nuclear test ban could be enforced.

Frederick C. Lindvall, chairman of the engineering division, heads a group of eight educators now touring Russia to study the quality of engineering instruction there.

The one-month inspection trip is a project of the American Society for Engineering Education. It was originally suggested by the Soviet Union, and the plan calls for Russian engineering educators to tour schools in this country, too.

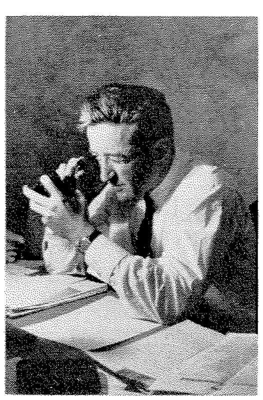
Donald E. Hudson, professor of mechanical engineering, is on leave of absence for six months to help develop a program of postgraduate studies at the University of Roorkee in India.

Dr. Hudson is making the trip under the sponsorship of the Technical Cooperation Mission to India, a program of the U.S. Department of State. The purpose of the project is to help raise the level of India's engineering and technology.

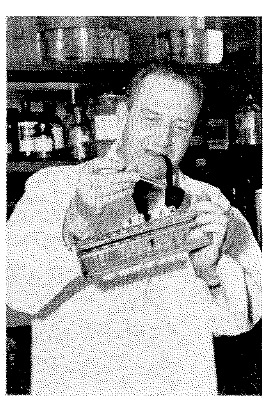
Roorkee University, about 100 miles north of New Delhi, is the oldest engineering school in Asia and was founded 100 years ago. The university is setting up a program of postgraduate studies as part of India's second five-year plan.

Dr. Hudson was invited to direct the installation of postgraduate laboratories and classes in mechanical

They Lead Off "The Next Hundred Years"

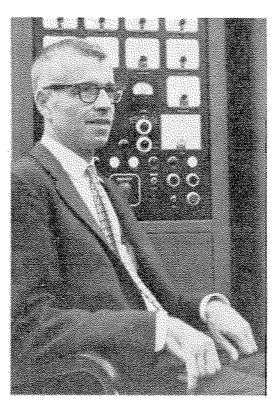


Brown: The Story of the Irish Potato

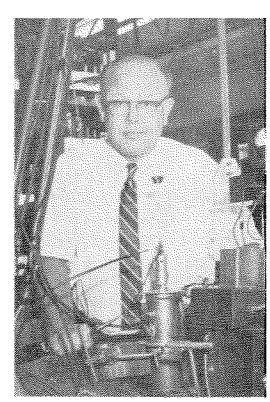


Owen: Facts for a Frankenstein

Jahns: Geological Russian Roulette



Clark: They'll Remember Grandma



Fowler: In the Beginning, Hydrogen

engineering a year ago when A. N. Khosla, president of Roorkee University, visited the United States and selected Caltech's engineering division as a model.

Space Program

Dr. Homer J. Stewart, Caltech professor of aeronautics and chief of the liquid propulsion systems division of the Jet Propulsion Laboratory, has been appointed director of the Office of Program Planning and Evaluation of the National Aeronautics and Space Administration. Dr. Stewart will be directly responsible to the NASA administrator, T. Keith Glennan.

Working with a small group of specialists in the areas of science and technology most closely associated with space problems, Dr. Stewart will be primarily responsible for planning programs in space technology and exploration. This work will be carried on in close consultation with the Department of Defense to produce a comprehensive, national space program.

Dr. Stewart is one of the pioneers in American rocketry; in 1939 he was a member of the small group of Caltech engineers and scientists who developed Jato and became the nucleus of the Jet Propulsion Laboratory. A native of Michigan, he received his BS in aeronautical engineering at the University of Minnesota in 1936, and his PhD in aeronautics at Caltech in 1940.

For some years, Dr. Stewart served as chief of the research analysis section of JPL, and in that capacity participated in many pioneering rocket projects, including the Wac Corporal, Corporal, Bumper, Sergeant and Jupiter C. As chief of the liquid propulsion systems division, he participated prominently in the joint effort of JPL and the Army Ballistic Missile Agency in developing and launching the first American earth satellite, Explorer I and subsequent Explorers.

Homer J. Stewart, new director of the NASA Office of Program Planning and Evaluation.

Abraham H. Maslow, psychologist, and first visitor on this year's Leaders of America program.

Leaders of America

Dr. Abraham H. Maslow, professor of psychology and chairman of the graduate committee in psychology at Brandeis University in Waltham, Mass., comes to the campus December 3-5 as the first visitor in this year's Leaders of America program, sponsored by the Caltech YMCA.

A distinguished lecturer, Dr. Maslow is also the author of *Motivation and Personality*, and co-author of *Principles of Abnormal Psychology*.

James B. Conant, second guest on the Leaders of America program, will be on campus from January 12-15. Former president of Harvard University (1933-1953) and U.S. High Commissioner for Germany (1953-1955). Dr. Conant is now engaged in a study to improve American high schools.

Will Herberg, the last of the year's Leaders of America, will be here from April 20-22. Graduate professor of Judaic studies and social philosophy at Drew University, he is currently on the staff of the Washington School of Psychiatry. He is known for his work in two fields – social research and theology. For many years he served as research analyst for a large AFL labor union. More recently, his major concern has been technology and social philosophy.

Alumni News

Homecoming Game

Caltech's Annual Homecoming Game is set for November 14, when the Beavers meet the Occidental Tigers at Occidental College. For the first time, the student body, alumni and guests will have dinner together before the game in Fleming and Ricketts Houses at 6:15 p.m. Caltech Coach Bert La Brucherie will discuss the game outlook and the Caltech Glee Club will entertain the guests. Bus transportation will be available for the whole party at 7:15 p.m. Those who cannot attend the dinner are invited to park their cars in Tournament Park and ride in the buses. Following the game, a dance will be held in the Fleming-Ricketts courtyard. Tickets will be available in Fleming Lounge before dinner – or at the California Street entrance of Tournament Park after dinner.

– John D. Gee, Homecoming Chairman

Call to Alumni

Alumni in 33 cities were linked together by telephone on October 7 in the largest alumni meeting of its kind in history.

Seated in his office on the campus, President DuBridge was able to talk to the 16-state assemblage on the occasion of the launching of the alumni drive for Caltech's Development Program.

Also speaking from President DuBridge's office were Alumni Secretary Donald Clark, Alumni President Edward Fleischer, and Arnold Beckman, Trustee of the Institute and chairman of the Development Program's executive committee.

Several hundred alumni, separated by as much as 3,000 miles, were able to talk to one another, and to hear recent news of the Development Program from headquarters in Pasadena. Thirty-three Development Program alumni division chairmen, meeting with their committees in their own cities, were able to report the receipt that night of new gifts amounting to about $50,000. Alumni contributions to the Development Program now total about $250,000.

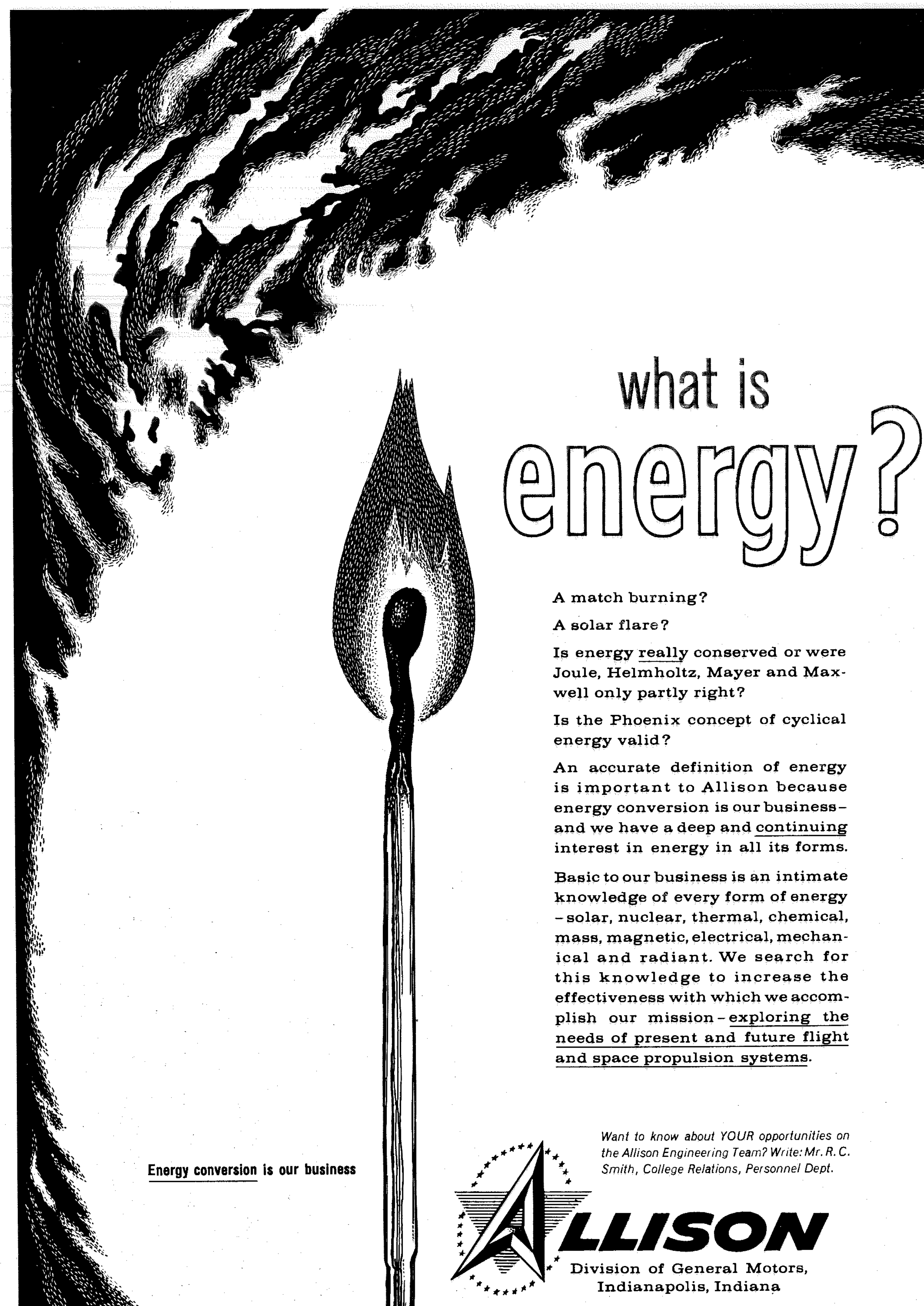
President DuBridge and Alumni Secretary D. S. Clark talk to Caltech alumni in 16 states.

Alumni Scholar

Richard Weinshilboum, a freshman from Augusta, Kansas, is the fifth Caltech student to receive an Alumni Scholarship. The award – a four-year, full-tuition grant made possible by an endowment created by Caltech alumni, through past contributions to the Alumni Fund – has been given each fall since 1954. Richard ranked first in his class at Augusta High School. He won a lettter in tennis and was a member of the school debate team as well. His father owns a home and auto supply store in Augusta, and there are three younger brothers and sisters. Richard is 18 now. After college he hopes to make a career in research in the physical sciences.

Long Beach Fund-Raisers

The Long Beach Area Special Gifts Committee and General Canvass Committee of the Caltech Development Program held a dinner meeting on October 7 when President DuBridge talked to 16 states about the launching of the general alumni canvass for the program. The telephone communication was carried over a loud speaker to the guests in the Le May patio and to neighbors over a considerable radius. The Long Beach Area was proud to announce that its goal


what is
energy?
A match burning?
A solar flare?
Is energy really conserved or were Joule, Helmholtz, Mayer and Maxwell only partly right?
Is the Phoenix concept of cyclical energy valid?
An accurate definition of energy is important to Allison because energy conversion is our business–and we have a deep and continuing interest in energy in all its forms.
Basic to our business is an intimate knowledge of every form of energy–solar, nuclear, thermal, chemical, mass, magnetic, electrical, mechanical and radiant. We search for this knowledge to increase the effectiveness with which we accomplish our mission–exploring the needs of present and future flight and space propulsion systems.
Energy conversion is our business
Want to know about YOUR opportunities on the Allison Engineering Team? Write: Mr. R. C. Smith, College Relations, Personnel Dept.
ALLISON
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of $12,000 had been substantially exceeded. A total of $15,750 was subscribed with more than 30 percent of the pledges yet to be turned in. The general canvass is under the guidance of *William Shippee '48*, general canvass committee chairman; and vice chairmen Tom Coleman, Pat Fazio and Dick Russell.

— *Dan LeMay, Special Gifts Committeeman*

New Appointment

Edward P. Fleischer, president of the Alumni Association, has been appointed assistant to the president of the Consolidated Electrodynamics Corporation in Pasadena. He has been with the company since 1951 when he received his MBA in business administration from Stanford University. At that time he began working in the engineering department, eventually serving as director of the department and, at the same time, as staff assistant to the vice president. He then became, successively, staff assistant to the president and manager of systems and procedures.

Ed Fleischer was elected to the Alumni Association board of directors in 1956 and served as co-chairman of the Fund Committee in 1956 and director in 1957-58. He became vice president of the Association in 1957 and president in 1958.

Among the Missing

The Caltech Alumni Association is trying to complete its file of Caltech publications and is still lacking some of the early issues of the school's annuals. Would anyone who has copies of the following publications be willing to send them to the Association?

The Polytechnic — 1896 through 1912
The Throop Tech — 1913 through 1915
The Big T — 1932

Be Well Informed

One of the many reasons you should subscribe to *The California Tech* is that this campus newspaper is the only way you can get a weekly account of the student activities at Caltech.

Subscriptions for the 1958-59 academic year are available for only $1.50. Write to:

Neil Sheeley
Circulation Manager
Blacker House, Caltech

Letters . . . *continued*

Livermore Radiation Laboratories, was to have headed up the full series of nuclear tests which were started last spring at Eniwetok. He was killed while making a night reconnaissance flight over the test site. In a sudden rain squall, his helicopter crashed in shallow water and death may have been due to the impact or subsequent drowning.

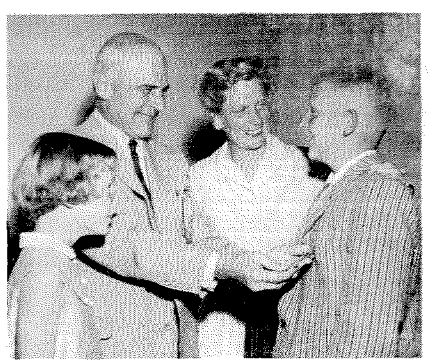
I had thought that since the accident was well covered by all the wire services a story would have been readily available to the editorial staff of the magazine. If the information was not available I am most regretful for not having written to you sooner.

In addition to the recounting of the details of the accident the newspapers subsequently carried accounts of the two posthumous awards which were extended to Mark's family in recognition of contributions to science and to the National Defense Effort. The first was the Freedom Award presented in June by Mr. Lewis Strauss, then Chairman of the Atomic Energy Commission, for "exceptionally meritorious service in contributing to the security of the United States of America and to the welfare of the human race."

The second award was the Air Force Service Award, presented by Lt. General James Doolittle in July, "in recognition of distinguished patriotic service."

The establishment of the annual graduate student award in memory of Mark was announced by the American Nuclear Society in June. It is to be given to outstanding graduate students working in the nuclear sciences.

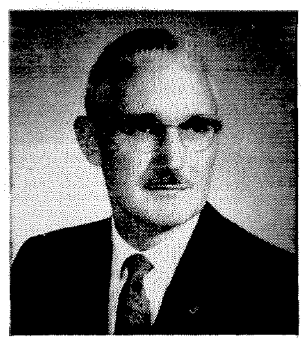
Charles F. Carstarphen, '39, MS '40
Plant Superintendent, Procter and Gamble Company

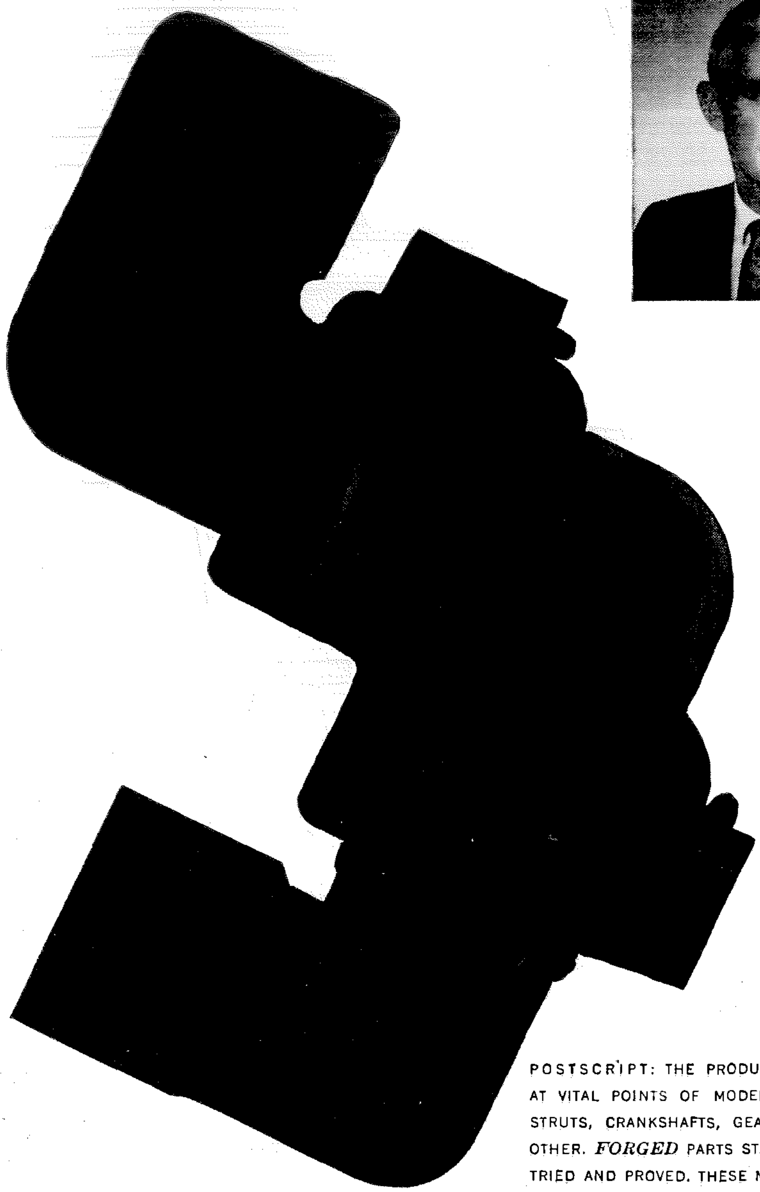


Mark Mills, Jr., 12, wears the Air Force Service Award given posthumously to his father by Lt. Gen. James Doolittle (USAF-Ret.). Mark's mother and sister, Ann, look on.

FORGED Parts are Free from Inside Faults

—sound from center to surface





"There's an 'inside story' to the forged parts we use for swivel joints on steel hose for oil producers. These joints work at pressures up to 15,000 lbs. per sq. in., temperatures to 600° F., and handle abrasives such as mixtures of oil and sand, and wet cement. Under such tough conditions the *forged* joints prove tight against leakage, safe against bursting, and have lasted for many years in such service. This remarkable durability is possible because the forged metal is sound, dense, non-porous *from center to surface.* Freedom from inside faults also saves production dollars; when we cut into the forged parts to machine precise, expensive ball-bearing races and accurate mating surfaces, we do not find inside faults that would cause rejections. Any way you look at it, this inside story helps us and our customers."

G. M. Bagnard
Chief Engineer,
Chiksan Company, makers of swivel joints, rotary hose, mud mixing guns.
(Subsidiary of Food Machinery and Chemical Corporation)

POSTSCRIPT: THE PRODUCTS OF THE FORGING INDUSTRY ARE FOUND AT VITAL POINTS OF MODERN CONVEYANCES AND MACHINES...LEVERS, STRUTS, CRANKSHAFTS, GEARS. THE FORGING PROCESS IS UNLIKE ANY OTHER. *FORGED* PARTS START WITH REFINED METALS—METALS ALREADY TRIED AND PROVED. THESE METALS ARE GIVEN ALMOST ANY DESIRED FORM OR SHAPE BETWEEN IMPRESSION DIES, UNDER ENORMOUS PRESSURE OR BY CONSECUTIVE BLOWS FROM POWERFUL HAMMERS. THE RESULT IS ADDED STRENGTH AND TOUGHNESS...WHICH PERMITS WEIGHT-SAVING DESIGNS, CUTS SERVICE COSTS, HELPS PROVIDE SAFETY IN A HIGH-SPEED WORLD.

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Personals

1920

Lloyd E. Towne, office manager of the Worthington Corporation in Los Angeles, died in October, 1956, of muscular dystrophy. He was 62. Lloyd started with Worthington in their Harrison, New Jersey, office in 1920 and came to Los Angeles in 1924 as a salesman, later becoming office manager. He is survived by a son, Roger, who is 20.

1930

Robert W. Wilson, PhD '36, associate professor of paleontology and associate curator of the Museum of Natural History at the University of Kansas, writes that he served as president of the Society of Vertebrate Paleontology in 1955, and spent the academic year 1956-57 in England, as a Guggenheim Fellow, working at the British Museum.

1935

James H. Jennison, MS '36, head of the product engineering division at the Naval Ordnance Test Station in Pasadena, reports that he recently received a superior accomplishment award for a design which cut the cost of a major missile component in half. "All things considered," he writes, "I find NOTS a good place to work and I am proud to be part of the capable organization here. Quite a few Caltech alumni are in key spots here—the most distinguished being our technical director, *William B. McLean,* '35, MS '37, PhD '39.

"We are just finishing a new house to accommodate our growing family. On September 20 our fourth child was born —a daughter, Wendy Lou. We have two other girls and a boy."

1936

Hugh F. Colvin, senior vice president of Consolidated Electrodynamics Corporation in Pasadena, has been reappointed to the U.S. Chamber of Commerce's committee on government expenditures for 1958-59.

1938

Charles W. Clarke, manager of division planning at the AiResearch Manufacturing Company in Los Angeles, sends along news of the 20th reunion of the class of 1938 which took place in June at the Rodger Young Auditorium in Los Angeles. Here are his notes:

Evan Johnson, president of the American Messer Corporation in Scarsdale, N.Y., won a bottle of bourbon for coming the longest distance to the reunion.

Tom Davis, MS '47, AE '48, senior engineer at the Boeing Airplane Company

continued on page 51

There's a Metal Problem in your future that Inco can help you solve

In the meantime, see if you can tell which nickel-containing alloy proved to be the answer to these problems.

Number the picture captions!

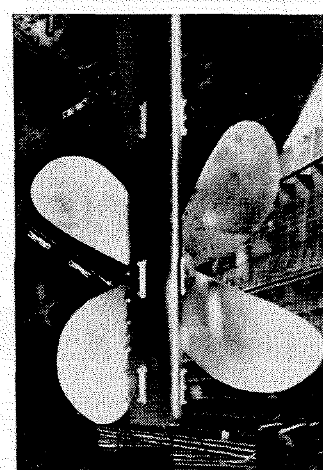
1 Nickel cast iron
2 Chromium-nickel stainless steel
3 4340 constructional alloy steel
4 Ductile Ni-Resist*
5 Cupro-nickel
6 Nickel-aluminum bronze
7 Ni-Resist nickel cast iron

*Registered trademark

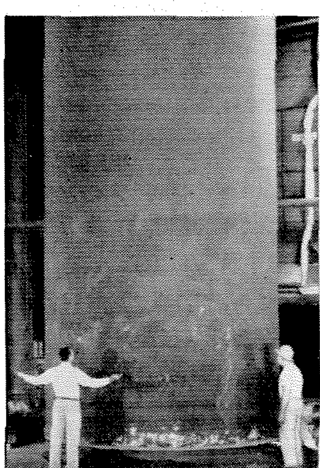
See answers below

☐ **Piston ring carrier insert**—Needed: wear resistance, thermal expansion to match aluminum. Which alloy?

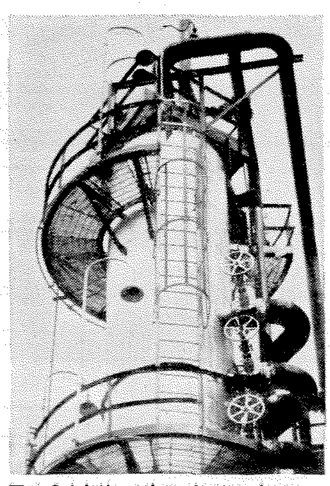
☐ **Grader drive axle**—Needed: toughness, impact resistance, greatest strength, with least weight. Which alloy?



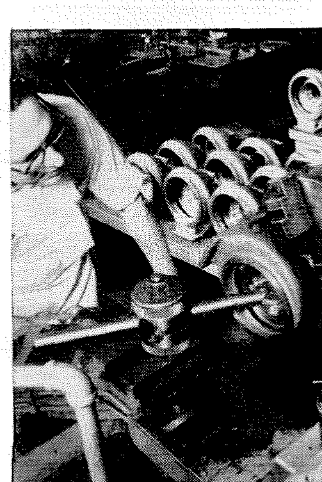
☐ **Ship's propeller** — Needed: light weight, high resistance to erosion, sea water corrosion. Which alloy?



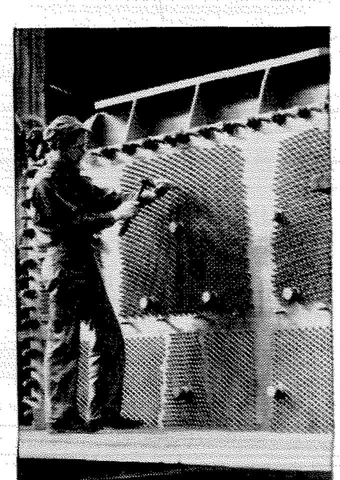
☐ **Yankee dryer roll** — Needed: high strength, uniform structure in cross sections of heavy castings. Which alloy?



☐ **Catalytic polymerization tower** — Needed: resistance to phosphoric acid at 375°F, 500 psi. Which alloy?



☐ **Turbocharger housing** — Needed: resistance to thermal shock, heat, corrosion at 1500°F. Which alloy?



☐ **High pressure marine condenser**— Needed: heat transfer, stress, corrosion resistance. Which alloy?

You may have to take this kind of quiz *again*. You may be designing a machine which requires a metal that resists corrosion . . . or wear . . . or high temperatures. Or one that meets some destructive *combination* of conditions.

When you start to design equipment, you will have to select the proper material to meet given service conditions. Over the years, Inco Development and Research has successfully solved many metal problems, and has compiled a wealth of information to help you.

For more on special problems solved with nickel-containing alloys, send for "Standard Alloys for Special Problems." Write The International Nickel Company, Inc., Dept. 189G, New York 5, N. Y.

The International Nickel Company, Inc.
New York 5, N. Y.

answers

- Piston ring carrier insert..........7 Ni-Resist
- Grader drive axle.......... 3 4340 constructional alloy steel
- Ship's propeller..6 Nickel-aluminum bronze
- Yankee dryer roll............1 Nickel cast iron
- Catalytic polymerization tower .... 2 Cr-Ni Stainless
- Turbocharger housing..4 Ductile Ni-Resist
- High pressure marine condenser.......... 5 Cupro-nickel

Inco Nickel
makes metals perform better, longer

Personals . . . *continued*

in Spokane, Washington, was runner-up for the prize.

Bill Nash, MS '39, PhD '42, assistant manager of operations at C. F. Braun & Company (who made all the arrangements for the reunion meeting room and bar facilities) took an independent poll and found that there were only 9 men out of the group who understood *Engineering and Science.*

George Holmes, controller at the Electrodata Division of the Burroughs Corporation in Pasadena, turned out to be the only man who could explain the satellite.

Roland Stone, a partner in the Superior Honey Company in Los Angeles, has discovered that the honey he manufacturers has turned out to be a catalyst in the development of male hormones.

Stan Wolfberg, senior consultant at Benjamin Borchardt & Associates in Los Angeles, is making a time study out at Rose Marie Reid, which includes intimate contact with the models.

Al Jurs, vice president in charge of the electrical division of the Shand & Jurs Company in Berkeley, is the most prolific of the '38 graduates, with a family of 6 children.

Don Clark, BS '29, MS '30, PhD '34, was unanimously nominated and elected as permanent class father of the class of 1938.

Letters and telegrams came from these absentees:

John G. McLean, vice president of coordination and planning at the Continental Oil Company in Houston, Texas: "Sorry I cannot be there. Family: Girl, 4; Boy, 2; Boy, 6 months."

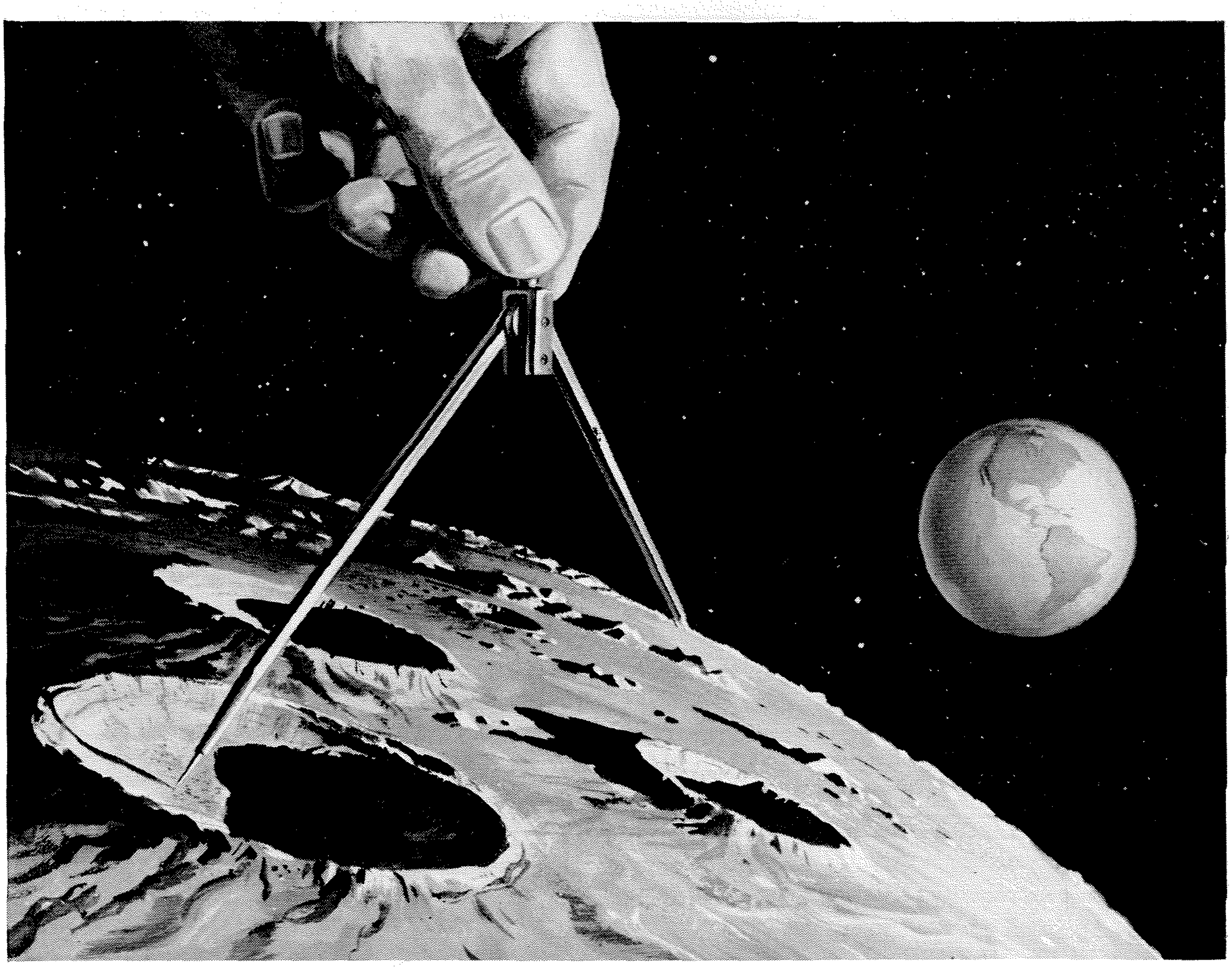
Frank Jewett, vice president and member of the board of directors of the Vitro Corporation of America in New York: "Best regards. Sorry I can't be with you. Made necessary business arrangements for trip but it was to wrong coast."

Paul Dennis, staff assistant to the general manager of the computer division of the Bendix Aviation Company in Los Angeles: "Greetings to all from Brussels."

Carl Friend, department engineer in the aerodynamics department of the Lockheed Aircraft Corporation in Atlanta: "Am trapped in Marietta, Ga."

Comdr. Dick Forward, U.S. Navy, writes: "The invitation reached me rather late since it tracked me down an obscure trail of forwarding addresses. I am still in the Navy and am serving at the moment in the Paradise of the Pacific – the Hawaiian Islands. As a matter of fact, my career seems to have developed in a

continued on page 53



Personals . . . *continued*

rut of rotation between Hawaii and Washington, D.C. We last escaped the home of the Great White Father in August, 1957, and are about nine months along in our stay in Hawaii.

"What am I doing out here? The short title COMBARPAC is a good cover-up. Could imply a corner saloon or an undercover auxiliary for the WCTU. Actually it means: Commander Barrier Pacific, which is the command in charge of the DEW line in the Pacific Ocean Area. I am officially titled Officer in Charge of Operations Control Center. This is a rather elaborate installation in which known traffic is compared with observed, and the unknown is labeled Hostile should the end-run around the DEW Line be attempted. In this unhoped-for event, we will push the first button in this age of pushbutton warfare."

Roger Cowie, geologist in the exploration department of the Shell Oil Company in New Orleans, La.: "I regret that I won't be able to compete for the jug of bourbon – but hope to make the next one 5 years hence. I have been living in south Louisiana since 1948 when I joined Shell, and in New Orleans since 1951. For the last 4 years I have been in charge of geological work in the marine exploration division concerned with oil exploration offshore of Louisiana. Beaucoup oil down here."

1943

David M. Mason, MS '47, PhD '49, has been made professor of chemical engineering and associate executive head of the newly-created division of chemical engineering at Stanford University, where he has been teaching since 1955. Before that, he was an instructor and research group supervisor at Caltech's Jet Propulsion Laboratory.

1945

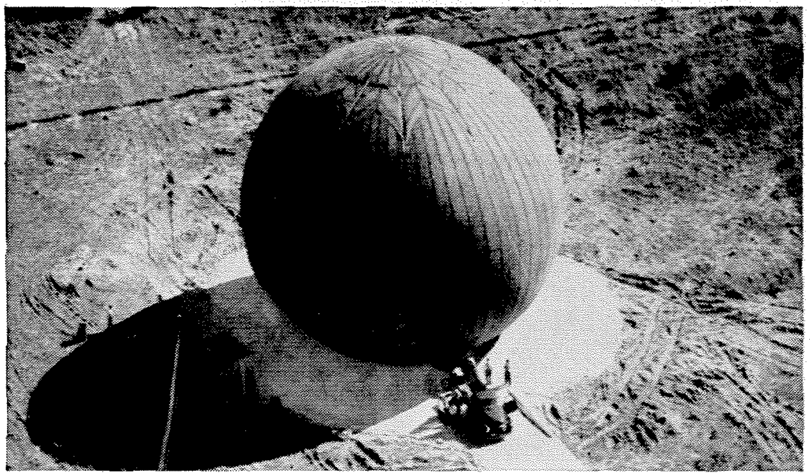
Robert D. Mason, assistant superintendent of the Muirson Label Company, Inc., in San Jose, Calif., died of acute nephritis and uremia on June 19, 1958, at the University of California Hospital in San Francisco. He had been with Muirson for 12 years. He leaves his wife, Rae, and two children, Nancy and David.

1947

Richard Davis, MS, is now working at the Stanford Research Institute at Palo Alto. He has three children–a boy, 13; a daughter, 4½, and a son, 2½. Dick received his PhD in mathematics at Berkeley in 1955.

Col. William M. Linton, MS, has assumed command of the 151st engineer group of the United States Army Infantry in Fort Benning, Georgia. He has been in the Army since 1955, when he

continued on page 54



Personals . . . *continued*

graduated from West Point. The Lintons have four children—David, 11; Barbara, 6; William F., 4, and Eugene, 1.

John W. Harrison received his PhD in English and Speech and English Literature from the University of Colorado in August.

1948

Phillip Eisenberg is now head of the mechanics branch of the Office of Naval Research in Washington, D.C.

Paul J. Howard, plant manager for Procter and Gamble in Baltimore, is the father of three girls—3, 5 and 7 years old.

Thomas P. Higgins, MS, has been appointed to head the research and development activities at Lockheed's Missile Systems division plant in Van Nuys. He has been at Lockheed for the past five years and was recently missiles and spacecraft department manager in preliminary design at the Burbank plant. The Higgins' have four children.

Charles Susskind, associate professor of electrical engineering at Berkeley, had a stay in Britain and on the continent during the summer with Terry (his fourth child), Pamela, 5; Peter, 3, and Amanda, 1. Charles also does some industrial consulting and, in his spare time, writes a weekly column on music that appears in several papers on the San Francisco peninsula, and broadcasts over KPFA-FM, the Berkeley listener-sponsored station.

1949

Paul H. Kidder received his MS in engineering at Ohio State University in August.

Jack N. Nielsen, MS, PhD '51, is a member of Vidya Associates, a research and development company just started in Palo Alto. Vidya is a group of prominent scientists concerned with research and development in aeronautics, thermodynamics and electronics. The Nielsens and their daughter live in Los Altos.

1950

John B. Rutherford, MS, has resigned his position with the Western-Knapp Engineering Company in San Francisco to open his own office for the practice of structural engineering in Los Altos.

William F. Jones, MS, has recently opened a soils engineering practice named Jones, Thenn and Associates in Mountain View, California.

J. Robert Holmes, development engineer in reliability engineering at the IBM Corporation in Owego, New York, has been promoted to development engineer in reliability analysis in the systems, evaluation and component engineering department of the company. Bob, his wife, and three sons live in Vestal, N.Y.

Personals . . . *continued*

1951

Robert J. Kurland has been appointed instructor in chemistry at the Carnegie Institute of Technology in Pittsburgh, Pa. He received his MA and PhD degrees from Harvard University.

1952

Dr. Ernest R. Cram, MS, writes: "It is always a pleasure to read *Engineering and Science* and I remain very proud of my Caltech degree. The training and practice I received in meterology aids me in many ways in my general practice of medicine.

"I have three children and am currently president of the local Rotary Club, chairman of the district Boy Scout committee, county coroner, and running for election on the high school board of trustees."

William R. Blake was recently elected president of the Lamicell Engineering Company of Baxter Springs, Kansas. The company has lately completed a thorough retooling program for the production of the Blake Wake-Breaker Water Ski, a fiberglass reinforced-plastic ski which will be announced to the trade in January.

1953

William C. Duesterhoeft, Jr., PhD, associate professor of electrical engineering at the University of Texas in Austin, has taught there for seven years. Last spring he won the $1,200 Convair award for excellence in engineering teaching for 1958.

1954

Jerry C. Mitchell is now a chemist in the polymer and chemical applications department of the Shell Development Company in Emeryville, Calif. He took his graduate work at Harvard University where he received his MA and PhD degrees in chemistry.

1955

Oscar Seidman, AE, writes that "after absorbing some learning at Caltech, I returned to the Bureau of Aeronautics of the Navy Department in Washington, where I am head of the Aero and Hydro Development Section. I may have to return for a refresher course at Caltech, however, as my daughter, 7, has mastered the anti-gravitational principles of the hula hoop (a Pasadena product) while I have not yet worked out a satisfactory solution."

1956

Alfred K. Orr, Jr., MS, writes from Tripoli in Libya, North Africa: "After leaving Pasadena two years ago, we moved to Tulsa, Okla., where we spent two grand years. We now have two chil-

continued on page 57

The huge Convair-Fort Worth plant is located on the western edge of Fort Worth, and is connected to all parts of the city by a system of limited access freeways.

Nearing completion at Convair-Fort Worth — the world's largest Altitude Chamber of its kind.

Bonded sandwich paneling-pioneered by Convair-Fort Worth — is fabricated in an almost unlimited variety of shapes and sizes.

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- Nearly half-a-hundred highly advanced Air Force contracts now on hand
- Extensive research and development equipment and facilities
- Broad educational and employee benefits
- First to employ the weapons system management concept
- Latest achievement . . . America's first supersonic bomber . . . the all new B-58

A resume of your training and experience will be evaluated by engineers in the department best suited to your particular qualifications.

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FORT WORTH, TEXAS
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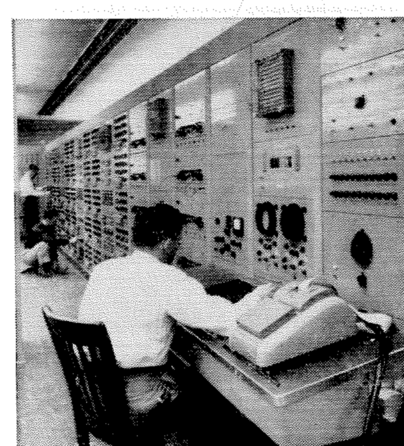
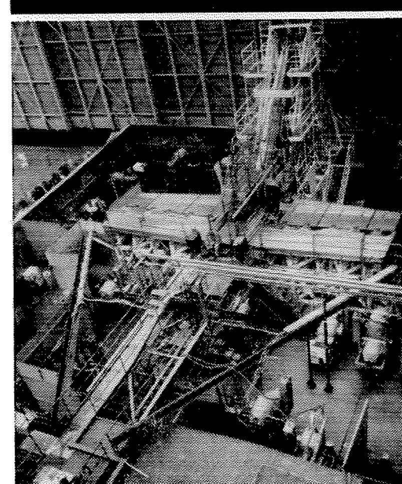


DAEAC — newest and most advanced facility — permits static, dynamic, flutter and steady-state areoelastic testing of the complete airplane by means of direct electrical analog.



Full scale mock-up and test stand for B-58 hydraulic powered flight control system.

Personals . . . *continued*

dren – Lisa, 2½, and Jean, 1. Working with the Ohio Oil Company in Tulsa was very pleasant – our closest friends there were *John Stick, Jr.*, '35, and his wife. A former classmate of *Richard Jahns* (professor of geology at Caltech), John is an engineer at the Lane-Wells Company.

"In July, my company sent me to Tripoli where I am working at the Oasis Oil Company of Libya (a division of the Ohio Oil Company). This is a very strange land – the former home of nine civilizations including Phoenicians, Greeks, Romans, Carthaginians, Berbers and Turks. Once the 'Granary of Rome,' it is now a barren desert with the exception of a narrow coastal area. The Sahara comes right to the sea along most of the coast. Although Arabic is the national language, Italian is probably spoken by more people. English is heard more and more.

"Tripoli is a city of some 250,000 people of which 40,000 are Italian, 20,000 British, and 10,000 Americans. The others are mostly Arab. The streets are narrow and filled with bicycles, small cars and donkey carts. The suburban streets are often crowded with sheep and camels. The first signal lights are being installed, but will probably be useless, since the bicycle riders pay no attention to street signs.

"Thousands of small shops sell everything imaginable. Most of the city is beautiful, especially that built by the Italians before the war. Tropical flowers and date palms are abundant along the streets and in the gardens."

1958

Robert L. Blakeley, Robert S. Deverill, Paul C. Minning and *Dennis G. Peters* are all doing graduate work on Woodrow Wilson Fellowships. Bob Blakeley is at Harvard University working in organic chemistry. Bob Deverill is at Caltech working in physical chemistry. Paul has entered the University of California at Berkeley for work in theoretical physics and Dennis is at Harvard working in chemistry.

Richard O. Hundley who is working for his PhD in physics at Caltech, now has a son, Richard William, born on July 25. Dick was married to Jan Vanderzee from Occidental two days after his graduation. He spent last summer working in the research lab at the Hughes Aircraft Company.

Morrow H. Moore, MS, is now assistant professor of mechanical engineering at George Washington University in Washington, D.C.

William Klement, Jr., is continuing graduate work in physics at Cornell University on a fellowship from the General Electric Company.

Lost Alumni

The Institute has no record of the present addresses of these alumni. If you know the current address of any of these men, please contact the Alumni Office, Caltech.

1906
Norton, Frank E.

1911
Lewis, Stanley M.

1921
Fletcher, Harold O.

1922
Cox, Edwin P.

1923
Hickey, George I.
Skinner, Richmond H.

1924
McKaig, Archibald
Mercereau, James T.
Tracy, Willard H.

1925
Bailey, Emerson

1926
Chang, Hung-Yuan
McCarter, Kenneth C.
Yang, Kai Jin

1927
Evjen, Haakon M.
Langer, R. Meyer

1928
Chou, P'ei-Yuan
Hicks, Hervey C.
Martin, Francis C.
Smith, Hampton

1929
Briggs, Thomas H., Jr.
Burns, Martin C.
Gilmore, Albert M.
Nagashi, Masahiro H.
Nelson, Julius
Robinson, True W.
Sandberg, Edward C.
Wolfe, Karl M.

1930
Chao, Chung-Yao
Douglass, Paul W.
Janssen, Philip
Moyers, Frank N.
Shields, John C.
White, Dudley

1931
Hall, Marvin W.
Ho, Tseng-Loh
Voak, Alfred S.
West, William T.
Woo, Sho-Chow
Yoshoka, Carl K.

1932
Patterson, J. W.
Schroder, L. D.
Watson, George G.
Wright, Lowell J.

1933
Applegate, Lindsay M.
Ashton, W. Andrew
Ayers, John K.
Downie, Arthur J.
Hsu, Chuen Chang
Koch, A. Arthur
Larsen, William A.
Lockhart, E. Ray
Michal, Edwin B.
Murdock, Keith A.
Rice, Winston H.
Shappell, Maple D.
Smith, Warren H.
Solomon, Hyman

1934
Harshberger, John D.
Liu, Yun Pu
Lutes, David W.
Radford, James C.
Read, John

1935
Becker, Leon
Ehrenberg, Gustave, Jr.
Huang, Fun-Chang
Kitusda, Kaname
McNeal, Don
Obatake, Tanemi

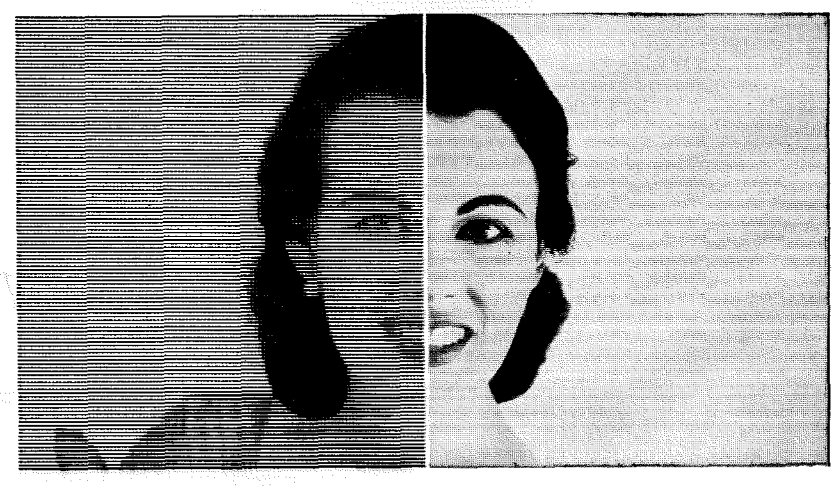
1936
Chu, Djen-Yuen
Creal, Albert
Dunn, Clarence L.
Isham, Arthur E. III
Kelch, Maxwell
Kurihara, Hisayuki
Ohashi, George Y.
Onaka, Takeji

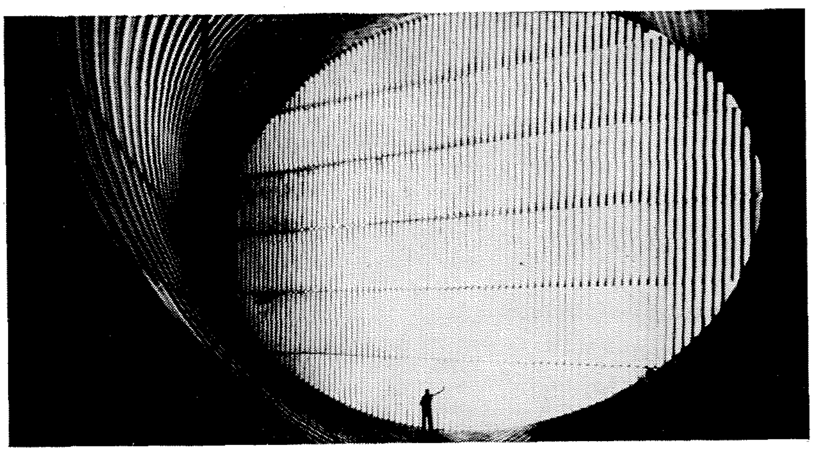
1937
Axelrod, Joseph
Bell, Willard N.
Burnight, Thomas R.
Chen, Ju-Yung
Easton, Anthony
Jones, Paul F.
Lotzkar, Harry
Maginnis, Jack
Moore, Charles K.
Munier, Alfred E.
Nojima, Noble
Penn, William L., Jr.
Rechif, Frank A.
Servet, Abdurahim
Shaw, Thomas N.

1938
Gershzohn, Morris
Goodman, Hyman D.
Hayward, Russell E.
Kanemitsu, Sunao
Lowe, Frank C.
Ofsthun, Sidney A.
Okun, Daniel A.
Tilker, Paul O.
Tsao, Chi-Cheng
Velazquez, Jose L.
Wang, Tsun-Kuei
Watson, James W.

1939
Asakawa, George
Brown, William L.
Easton, R. Loyal
Fan, Hsu Tsi
Goodin, Harry A., Jr.
Hopper, Richard H.
Liang, Carr Chia-Chang
Neal, Wilson H.
Robertson, Francis A.
Tatom, John F.
Tsien, Hsue-shen

1940
Batu, Buhtar
Green, William J.
Hsu, Chang-Pen
Menis, Luigi





Lost Alumni . . . *continued*

Paul, Ralph G.
Payne, Charles M.
Tao, Shih Chen
Tajima, Yuji A.
Ustel, Sabih A.
Wang, Tsung-Su

1941

Arnold, John K.
Blake, Charles L.
Clark, Morris R.
Dieter, Darrell W.
Easley, Samuel J.
Feeley, John M.
Frank-Jones, Glyn
Geitz, Robert C.
Green, Jerome
Harvey, Donald L.
Hubbard, Jack M.
Kuo, I. Cheng
Robinson, Frederick G.
Standridge, Clyde T.
Stephenson, William B.
Taylor, D. Francis
Tiemann, Cordes F.
Waigand, LeRoy G.
White, John R.
Whitfield, Hervey H.
Yui, En-Ying

1942

Bebe, Mehmet F.
Callaway, William F.
Chastain, Alexander
Go, Chong-Hu
Hughes, Vernon W.
Levin, Daniel
MacKenzie, Robert E.
Martinez, Victor H.
Sternberg, Joseph

1943

Angel, Edgar P.
Belmont, Arthur D.
Bethel, Horace L.
Bridgland, Edgar P.
Bryant, Eschol A.
Burlington, William J.
Carlson, Arthur V.
Colvin, James H.
Daniels, Glenn E.
Hamilton, William M.
Hewson, Lawrence
Hillyard, Roy L.
Hilsenrod, Arthur
Johnsen, Edwin G.
King, Edward G.
Koch, Robert H.
Kong, Robert W.
LaForge, Gene R.
Lee, Edwin S., Jr.
Leeds, William L.
Ling, Shih-Sang
Lobban, William A.
Lundquist, Roland E.
Mampell, Klaus
McNeil, Raymond F.
Mixsell, Joseph W.
Neuschwander, Leo Z.
Nesley, William L.
Mowery, Irl H., Jr.
Newton, Everett C.
O'Brien, Robert E.
Patterson, Charles M.
Pearson, John E.
Rambo, Lewis
Roberts, Fred B.
Rivers, Nairn E.
Rupert, James W., Jr.
Scholz, Dan R.
Shannon, Leslie A.
Smitherman, Thomas B.
Stewart, John T. D.
Tindle, Albert W., Jr.
Vicente, Ernesto
Washburn, Courtland L.
Walsh, Joseph R.
Wood, Stanley G.

1944

Alpah, Rasit H.
Baranowski, John J.
Barriga, Francisco D.
Bell, William E.
Benjamin, Donald G.
Berkant, Mehmet N.
Birlik, Ertugrul
Burch, Joseph E.
Burke, William G.
De Medeiros, Carlos A.
Feblowicz, Ernst A.
Fu, Ch'eng Yi
Gray, J. Doyle
Harrison, Charles P.
Hu, Ning
Johnson, William M.
Kern, Jack C., Jr.
Labanauskas, Paul J.
Leenerts, Lester O.
Marshall, John W.
Nicholson, James C.
Pi, Te-Hsien
Sakamoto, Arthur
Shults, Mayo G.
Taylor, Garland S.
Sullivan, Richard B.
Sunalp, Halit
Stanford, Harry W.
Stein, Roberto L.
Trimble, William M.
Unayral, Nustafa
Wadsworth, Jos. F., Jr.
Williams, Robert S.
Wolf, Paul L.
Wood, George M.
Writt, John J.
Yik, George

1945

Ari, Victor A.
Bunze, Harry F.
Gibson, Charles E.
Jenkins, Robert P.
Kuo, Yung-Huai
Romney, Carl F.
Tseu, Payson S.

1946

Allison, Charles W., Jr.
Barber, John H.
Burger, Glenn W.
Conradt, Robert H.
Davis, Donovan C.
Dethier, Bernard
Dyson, Jerome P.
Esner, David R.
Foster, R. Bruce
Hayne, Benjamin S., III
Hege, Douglas W.
Hoffman, Charles C.
Kempton, Calvin E.
KeYuan, Chen
Lang, Serge
Lewis, Frederick W.
Lowery, Robert H.
MacDonald, Norman J.
Maxwell, Frederick W.
Prasad, K. V. Krishna
Simmons, George F.
Sledge, Edward C.
Smith, Harvey F.
Tung, Yu-Sin
Uberoi, Mahinder S.
Weldon, Thomas F.
Weitzenfeld, Daniel K.

1947

Atencio, Adolfo J.
Clements, Robert E.
Clock, Raymond M.
Dagnall, Brian D.
Darling, Donald A.

The Explorer Satellites
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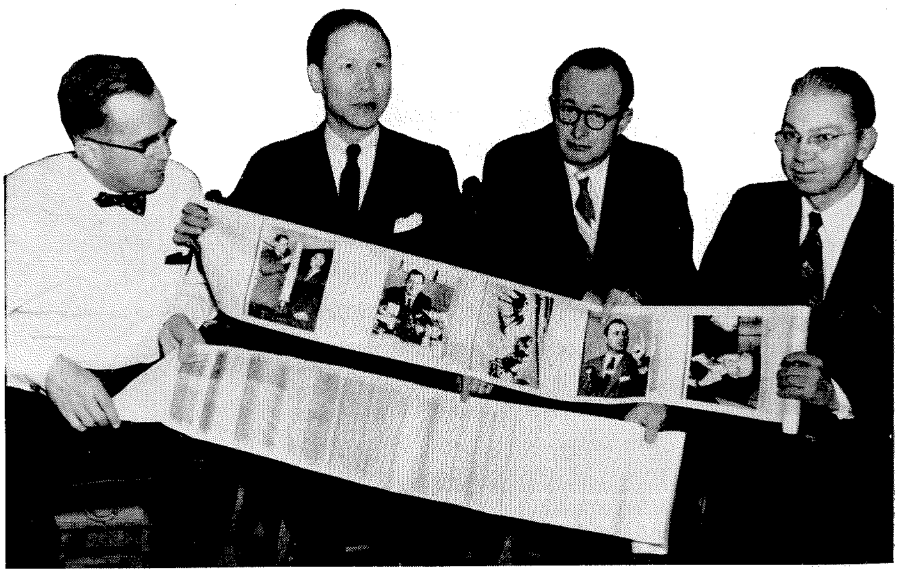

The top sheet in the illustration at the left is an Associated Press illustrated release. The bottom sheet represents recorded data sent from the U. S. Army Explorer I Satellite.

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Lost Alumni . . . *continued*

Hsu, Chi-Nan
Hsueh, Chi-Hsun
Huang, Ea-Qua
Leo, Fiorello R.
MacAlister, Robert S.
Manning, Ordway T.
McClellan, Thomas R.
Miller, Curtis E.
Molloy, Michael K.
Monoukian, John
Moorehead, Basil E. A.
Nelson, Conrad N.
Nevis, Arnold H.
Orr, John L.
Sappington, Merrill H.
Terminal, Ramon S.
Vanden Heuvel, Geo. R.
Van Dyke, Milton D.
Wan, Pao Kang
Wellman, Alonzo H., Jr.
Ying, Lai-Chao

1948

Agnew, Haddon W.
Bingham, Andrew T.
Blue, Douglas K.
Browne, Charles L., Jr.
Bunce, James A.
Collins, Burgess F.
Crawford, William D.
Garber, Max
Hager, James W.
Hlavka, George E.
Holm, John D.
Hsiao, Chien
Hsieh, Chia Lin
Latson, Harvey H., Jr.
Leavenworth, C. D.
Mason, Herman A.
McCollam, Albert E.
Morehouse, Gilbert G.
Oliver, Edward D.
Rhynard, Wayne E.
Robinson, Martin S.
Swain, John Sabin
Swank, Robert K.
Walters, James W., Jr.
Winniford, Robert S.
Woods, Marion C.
Yanak, Joseph D.

1949

Barker, Edwin F., Jr.
Bauman, John L., Jr.
Baumann, Laurence I.
Clancy, Albert H., Jr.
Clendening, Herbert C.
Cooper, Harold D.
Dannan, John H.
Foster, Francis C.
Galstan, Robert H.
Heiman, Jarvin R.
Krasin, Fred E.
Laberge, Jerome G.
Lowrey, Richard O.
MacKinnon, Neil A.
McElligott, Richard H.
Merrell, Richard L.
Orme, Eric C.
Petty, Charles C.
Ringness, William M.
Rudin, Marvin B.
Stappler, Robert F.
Weiss, Mitchell
Yi, Sien-Chiue

1950

Bryan, William C.
Hendrickson, James B.
Knoepfler, Peter T.
Li, Chung Hsien
McDaniel, Edward F.
McMillan, Robert
Nelson, Robert C.
Pao, Wen Kwe
Paulson, Robert W.
Petzold, Robert F.
Roberts, Morton S.
Roddick, James A.
Scherer, Lee R., Jr.
Schneider, William P.
Vivian, James A.

1951

Arosemena, Ricardo M.
Brewer, Richard G.
Chong, Kwok-Ying
Davison, Walter F.
Denton, James Q.
Goerke, Rudolph J., III
Hawk, Riddell L.
Lafdjian, Jacob P.
Li, Cheng-Wu
Padgett, Joseph E., Jr.
Palmer, John M., Jr.
Pfeiffer, Walter F.
Summers, Allen J.
Taylor, Richard B.

1952

Abbott, John R.
Arcoulis, Elias G.
Baugher, John D.
Cook, Samuel P.
Edelson, Leon
Gerington, Thomas E.
Guess, Arnold W.
Jepson, James O.
Loftus, Joseph F.
Long, Ralph F.
Lunday, Adrian C.
O'Brien, Joseph
Price, Edgar P.
Primbs, Charles L.
Robieux, Jean
Schaufele, Roger D.
Shelly, Thomas L.
Weber, Ernesto J.
Wiberg, Edgar
Woods, Joseph F.
Zacha, Richard B.

1953

Appleman, Daniel E.
Clark, David J.
Fink, George B.
Helmkamp, George K.
Lennox, Stuart G.
Mishaan, Alberto
Morishita, Naoji
Twining, David S.
Vidal, Jean L.

1954

Jimenez, Herberto
Kerr, William E.
Mertz, Charles, III
Quiel, Norwald R.
Sargent, Howard L., Jr.

1955

Crowe, Thomas H.
Hamzawi, Hashim H.
Moore, William T.
Muraru, Vasile

1956

Bradford, Robert E.
Herzog, Robert T.
Hsu, Nan-Teh
Nomicos, George N.
Spence, William N.

1957

Breitbard, Gary Y.
Stiffler, Jack J.
Tennant, Terrance H.
Yount, David E.

1958

Grell, Ellsworth H.
Schenter, Robert E.
Zeilenga, Jack H.

CALTECH CALENDAR

ALUMNI EVENTS

November 14	Homecoming Game and Dance
January 22	Winter Dinner Meeting
March 7	Annual Dinner Dance
April 11	Annual Seminar
June 10	Annual Meeting
June 27	Annual Picnic

ATHLETIC SCHEDULE

Football

November 14
Caltech at Occidental

November 22
Caltech at Claremont-Harvey Mudd

Water Polo

November 14
Pomona at Caltech

November 18
Caltech at Claremont-Harvey Mudd

November 21
Occidental at Caltech

Soccer

November 15
Santa Ana at Caltech

November 22
Redlands at Caltech

November 26
Caltech at Riverside

FRIDAY EVENING DEMONSTRATION LECTURES

Lecture Hall, 201 Bridge, 7:30 p.m.

November 14
High Energy Accelerators for Nuclear Physics
— Dr. Robert Langmuir

November 21
How to Create a More Effective Foreign Service
— Dr. Rodman Paul

December 5
Sedimentation of Small and Large Molecules in the Ultracentrifuge
— Dr. Jerome Vinograd

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Shell Development Co., Emeryville

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U. S. Navy Electronics Laboratory

One of a series

Interview with General Electric's Frank T. Lewis Mgr., Manufacturing Personnel Development

The Next Four Years: Your Most Important

The United States is now doubling its use of electrical energy every eight years. In order to maintain its position as the leading manufacturer in this fast-growing electrical industry, General Electric is vitally interested in the development of young engineers. Here, Mr. Lewis answers some questions concerning your personal development.

Q. Mr. Lewis, do you think, on entering industry, it's best to specialize immediately, or get broad experience first?

A. Let me give you somewhat of a double-barreled answer. We at General Electric think it's best to get broad experience in a specialized field. By that, I mean our training programs allow you to select the special kind of work which meets your interests—manufacturing, engineering, or technical marketing—and then rotate assignments to give you broad experience within that area.

Q. Are training assignments of a predetermined length and type or does the individual have some influence in determining them?

A. Training programs, by virtue of being programs, have outlined assignments but still provide real opportunities for self-development. We try our best to tailor assignments to the individual's desires and demonstrated abilities.

Q. Do you mean, then, that I could just stay on a job if I like it?

A. That's right. Our programs are both to train you and help you find your place. If you find it somewhere along the way, to your satisfaction and ours, fine.

Q. What types of study courses are included in the training programs and when are the courses taken?

A. Each of our programs has graduate-level courses conducted by experienced G-E engineers. These courses supplement your college training and tie it in with required industrial techniques. Some are taken on Company time, some on your own.

Q. What kind of help do you offer employees in getting graduate schooling?

A. G.E.'s two principal programs of graduate study aid are the Honors Program and the Tuition Refund Program. If accepted on the Honors Program you can obtain a master's degree, tuition free, in 18 months while earning up to 75% of full-time salary. The Tuition Refund Program offers you up to 100% refund of tuition and related fees when you complete graduate courses approved by your department manager. These courses are taken outside normal working hours and must be related to your field of work.

Q. What are the benefits of joining a company first, then going into military service if necessary.

A. We work it this way. If you are hired and are only with the Company a week before reporting to military service, you are considered to be performing continuous service while you are away and you will have your job when you return. In determining your starting salary again, due consideration is given experience you've gained and changes in salary structure made in your absence. In addition, you accrue pension and paid-vacation rights.

Q. Do you advise getting a professional engineer's license? What's it worth to me?

A. There are only a few cases where a license is required at G.E., but we certainly encourage all engineers to strive for one. At present, nearly a quarter of our engineers are licensed and the percentage is constantly increasing. What's it worth? A license gives you professional status and the recognition and prestige that go with it. You may find, in years to come, that a license will be required in more and more instances. Now, while your studies are fresh in your mind, is the best time to undertake the requirements.

Your next four years *are* most important. During that period you'll undoubtedly make your important career decisions, select and complete training programs to supplement your academic training, and pursue graduate schooling, if you choose. These are the years for personal development — for shaping yourself to the needs of the future. If you have questions still unanswered, write to me at Section 959-6, General Electric Co., Schenectady 5, N. Y.

LOOK FOR other interviews discussing: • Salary • Advancement in Large Companies • Qualities We Look for in Young Engineers.

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